MEDICAL INFORMATICS

PRACTICAL GUIDE FOR THE HEALTHCARE PROFESSIONAL

Third Edition

Robert E Hoyt *Editor*

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Medical Informatics

Practical Guide for the Healthcare Professional

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Editor

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Medical Informatics
Practical Guide for the Healthcare Professional

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Preface to the Third Edition

Compiling and editing this third edition has been challenging because of the non-stop changes occurring in Medical Informatics in 2009. In some respects this has been a banner year because of new opportunities related to the American Recovery and Reinvestment Act. The stimulus package will undoubtedly impact multiple areas of health information technology, to include electronic health records, health information exchanges and informatics research.

We have made every attempt to provide the most up to date information about Medical Informatics issues by constantly reviewing the medical and lay literature. Our goal is to present the most recent changes, the most interesting concepts and both sides of each controversy. Our book is intended to be an introduction to the field of Medical Informatics that will entice individuals to go further in their education.

In our experience, individuals from all walks of life seem to be interested in this relatively new field. We hope our book will better educate technology workers about clinical issues and better educate clinical workers about technology issues.

Given the newness of this field, research may be lacking or inadequate in many areas of Medical Informatics. We have to rely on surveys and expert opinions in many areas. Frequently, this can result in more noise than signal and more hype than fact. We are dedicated to presenting the issues fairly and objectively. Approximately 1200 medical literature references and web links are included in this book that direct readers to more information.

While we are vendor-agnostic we are not opposed to presenting interesting hardware and software we think will be of interest to our readers. This will include all relevant open-source initiatives. One of the goals of this book is to promote and disseminate innovations that might help healthcare workers as well as technology developers. The fact we mention specific hardware or software or web-based applications does not mean we endorse the vendor; instead, it is our attempt to highlight an interesting concept that might lead others in a new direction.

In our 2009 book we have added new content to each chapter and added chapters on practice management systems and networks. Chapters on electronic health records and mobile technology have been completely redone, reflecting the rapid change in those areas. Also, the HITECH Act as part of the stimulus package is discussed in regards to its impact on Medical Informatics in the first chapter.

We hope that you will see interrelationships between the topics mentioned in multiple chapters in this book. Articles written on the use of technology to improve patient care often involve telemedicine, patient safety, patient informatics, disease management and evidence based medicine.

Our book's emphasis will always be on the medical issues that the average clinician or hospital faces, with solutions that are easy to understand. We won't be reluctant to present the obstacles new innovations face or negative publications written on the subject. If we can introduce you to a single new concept or tool that improves patient care or makes your day easier, we will consider our work successful.

We appreciate feedback regarding corrections or future additions. We welcome your input so we can continue to publish the most accurate and up-to-date information.

Please note that all proceeds will be donated to the University of West Florida Foundation for the advancement of Medical Informatics education.

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1

Overview of Medical Informatics

ROBERT E. HOYT

Learning Objectives

After reading this chapter the reader should be able to:

- State the definition and origin of Medical Informatics
- Identify the forces behind Medical Informatics
- Describe the key players involved in Medical Informatics
- State the impact of the HITECH Act on Medical Informatics
- List the barriers to health information technology (HIT) adoption
- Describe the educational and career opportunities in Medical Informatics

"*I think there is a world market for maybe five computers*"
IBM Chairman Thomas Watson, 1943

Medical informatics has evolved as a new field in a relatively short period of time. Its emergence is partly due to the multiple challenges facing the practice of medicine today. As an example, clinicians need to: be more efficient, migrate away from paper based-records, reduce medication errors and have educational and patient related information at their fingertips. Technology has the potential to help with each of those areas. With the advent of the Internet, high speed computers, voice recognition, wireless and mobile technology, healthcare professionals today have many more tools available at their disposal. However, technology is advancing faster than healthcare professionals can assimilate it into their practice of medicine. In this chapter we will present an overview of Medical Informatics with emphasis on the factors that helped create this new field and the key players involved.

Definitions

The definition of Medical Informatics is dynamic due to the rapidly changing nature of both medicine and technology. The following are three definitions frequently cited:

> *"scientific field that deals with resources, devices and formalized methods for optimizing the storage, retrieval and management of biomedical information for problem solving and decision making"*[1]
>
> *"application of computers, communications and information technology and systems to all fields of medicine - medical care, medical education and medical research"*[2]
>
> *"understanding, skills and tools that enable the sharing and use of information to deliver healthcare and promote health"*[3]

Medical Informatics is also known as *Health Informatics, Clinical Informatics* and *Bioinformatics* in some circles. However, the consensus is that *Bioinformatics* involves the integration of biology and technology and can be defined as the:

> *"analysis of biological information using computers and statistical techniques; the science of developing and utilizing computer databases and algorithms to accelerate and enhance biological research"*[4]

Some prefer *Biomedical Informatics* because it encompasses Bioinformatics and medical, dental, nursing, public health, pharmacy, medical imaging and veterinary informatics.[5] As we move closer to integrating human genetics into the day-to-day practice of medicine this more global definition may gain traction. We have chosen to use Medical Informatics throughout the book for consistency.

Background

Given the fact that most businesses incorporate technology into their enterprise fabric, one could argue that it was just a matter of time before the tectonic forces of medicine and technology collided. As more medical information was published and more medical data was available, as a result of computerization, the need to automate, collect and analyze data arose. Also, as new technologies such as electronic health records appeared, ancillary technologies such as disease registries, voice recognition and picture archiving and communication systems arose to augment functionality. In turn, these new technologies prompted the need for expertise in health information technology that spawned new specialties and careers.

Medical Informatics emphasizes *information brokerage;* the sharing of a variety of information back and forth between people and healthcare entities. Examples of medical information that needs to be shared: lab results, x-ray results, vaccination status, medication allergy status, consultant's notes and hospital discharge summaries. Medical Informatics harnesses the power of information technology to expedite the transfer and analysis of data, leading to improved efficiencies and knowledge. The field also interfaces with other fields such as the clinical sciences, computer sciences, library sciences and public health sciences, to mention a few.

Health Information Technology (HIT) interfaces with many important functions in healthcare organizations and serves as a common thread that facilitates these functions (figure 1.1). This is likely the reason the Joint Commission created the management of information standard for hospital certification.[6] Although not included in the diagram, information systems that deal with the financial aspects of healthcare (practice management, claims submission, etc) are critical to healthcare organizations.

Many aspects of Medical Informatics noted in figure 1.1 are interconnected. For example, a healthcare organization is concerned that too many of its diabetics are not well controlled and believes it would benefit by offering a diabetic web portal. With a portal, diabetics can upload blood sugars and blood pressures to a central web site so that diabetic educators and/or clinicians can analyze the results and make recommendations. The following technologies and issues are involved with just this one initiative:

- The web based portal involves consumer informatics and telemedicine (chapters 6 and 16)
- Management of diabetes requires online medical resources, evidence based medicine, clinical practice guidelines and disease management-disease registries (chapters 7, 10, 11 and 12)
- If the use of the diabetic web portal improves diabetic control, clinicians may be eligible for improved reimbursement, known as pay-for-performance (chapter 13)

There are multiple forces driving the adoption of health information technology, but the major ones are the need to: decrease cost, improve patient safety and standardize and improve the quality of medical care. In this book we will discuss each driving force and their inter-relationships. In addition to these three forces, the natural diffusion of technology also exerts an influence. As

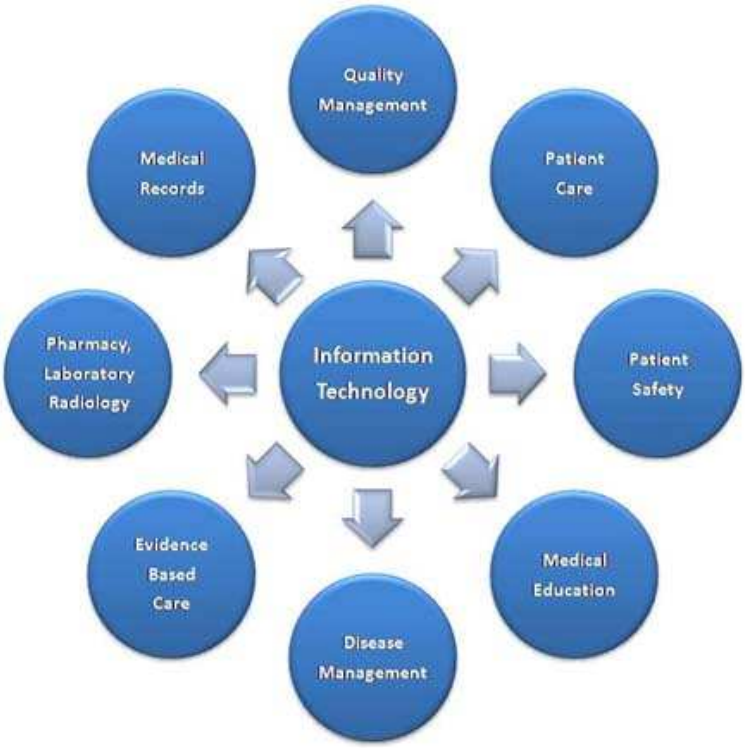

Figure 1.1 Healthcare functions and information technology

technologies such as wireless and voice recognition improve and mature, new applications will arise that have applicability to the field of medicine. Technological innovations appear at a startling pace as demonstrated by Moore's Law.

"*The number of transistors on a computer chip doubles every 1.5 years*"[7]
Gordon Moore, co-founder Intel Corporation 1965

Moore's Law pertains to the exponential growth of transistors in computers but the same growth holds true for technology in general. Technology will continue to evolve at a rapid rate but it is important to realize that it often advances in an asynchronous manner. For example, laptop computers have advanced greatly with excellent processor speed and memory but their utility is limited due to a battery life of only several hours. This is a significant limitation given the fact that most nurses now work 8-12 hour shifts, so short battery life currently limits the utility of laptop computers in healthcare.

The electronic health record (EHR), covered in chapter two, could be considered the centerpiece of Medical Informatics with its potential to improve patient safety, productivity and data retrieval. Although the current adoption rate is low, EHRS will likely become the focal point of all patient encounters in the future (fig.1.2). Multiple resources that are currently standalone programs will be incorporated into the EHR. It is anticipated that EHR use will eventually be shown to improve patient outcomes like morbidity and mortality as a result of decision support tools that decrease medication errors and standardize care with embedded clinical guidelines. With improved quality, clinicians will be paid more through pay for performance programs. All of these topics are

discussed in other chapters. Not included in the diagram is genetic information that will be part of all medical records in the future.

Figure 1.2 Electronic health record (EHR) dynamics.

It is also important to realize that one of the outcomes of EHRs will be the production of voluminous healthcare data. As pointed out by Steve Balmer, the CEO of Microsoft, there will be an "explosion of data" as a result of automating and digitizing multiple medical processes.[8] Adding new technologies such as electronic prescribing and regional health information organizations will produce data that heretofore has not been available. This explains, in part, why technology giants such as Microsoft, IBM and Google are now entering the healthcare arena. As we begin mining medical data from entire regions or organizations we will be able to make much better evidence based decisions. New tools such as natural language processing will help in mining the data.

The introduction of information technology into the practice of medicine has been tumultuous for many reasons. Not only are new technologies expensive, but also physicians and nurses are frequently not adequately trained in technology. This training rarely occurs in medical or nursing school or after graduation. More healthcare professionals who are "bilingual" in technology and medicine will be needed for the implementation and training of new technologies. Vendors, insurance companies and governmental organizations will also be looking for the same expertise. In 2005 the American Medical Informatics Association created the *AMIA 10x10 Program* with the goal of training 10,000 healthcare workers in Medical Informatics by the year 2010.[9] This timeline corresponds to the national plan to have a universal interoperable electronic health record system by 2014.[10]

Historical Highlights

Information technology has been pervasive in the field of Medicine for only about three decades. During this time we have experienced astronomical advances in technology to include personal computers, high resolution imaging, the Internet and wireless, to mention only a few. In the beginning there was no strategy or vision as to how to advance healthcare using information

technology. Now we have the involvement of multiple federal and private agencies that are plotting the future course for health information technology. The following are some of the more noteworthy developments in health information technology:

- **Computers**. The first general purpose computer (ENIAC) was released in 1946 and required 1000 sq ft of floor space. IBM developed the first personal computer in 1982 with a total of 16 K of memory.[11] Computers were first theorized to be useful for medical diagnosis and treatment by Ledley and Lusted in the 1950's.[12] They reasoned that computers could archive and process information more rapidly than humans.
- **Origin of Medical Informatics.** It is thought that the origin of the term Medical Informatics dates back to the 1960's in France ("Informatique Medicale").[13]
- **MEDLINE.** In the mid-1960's MEDLINE and MEDLARS were created to organize the world's medical literature. For older clinicians who can recall trying to research a topic using the multi-volume text *Index Medicus*, this represented a quantum leap forward.
- **Artificial Intelligence.** Artificial intelligence medical projects such as MYCIN (University of Pittsburg) and INTERNIST-1 (Stanford) appeared in the 1970's.[14]
- **Internet.** The development of the Internet began in 1969 with the creation of the government project ARPANET.[15] The World Wide Web was conceived by Tim Berners-Lee in 1990 and the first web browser Mosaic appeared in 1993.[16-17] The Internet is the backbone for digital medical libraries, health information exchanges and web based medical applications, to include electronic health records.
- **Electronic Health Record.** The electronic health record has been discussed since the 1970's and recommended by the Institute of Medicine in 1991.[18]
- **Handheld technology.** The PalmPilot PDA appeared in 1996 as the first truly popular handheld computing device.[19] Personal Digital Assistants (PDAs) loaded with medical software became standard equipment for any resident in training. They have been quickly supplanted by smartphones like the iPhone. PDAs and smartphones will be discussed in more detail in the chapter on mobile technology.
- **Human Genome Project.** In 2003 the Human Genome Project (HGP) was completed after thirteen years of international collaborative research. To map all human genes was one of the greatest accomplishments in scientific history. Although the project is complete, it will take years to analyze the data.[20] Data from mega-databases will likely change the way we practice medicine in the future. The HGP will be discussed in the chapter on Bioinformatics.
- **Nationwide Health Information Network.** The concept was developed in 2004 as the National Health Information Infrastructure and renamed the Nationwide Health Information Network (NHIN). The goal of the NHIN is to connect all electronic health records, regional networks and government agencies into one system, in one decade.[21] Achieving interoperability among all healthcare systems and workers in the United States will be a monumental challenge. This will be discussed in more detail in several other chapters.

Key Players in Health Information Technology

Information Technology is important to multiple players in the field of Medicine. The common goals of these different groups are to:

- Reduce medical errors and resultant litigation

- Provide better return on investment (ROI)
- Improve communication and continuity among the key players
- Improve the quality of care
- Reduce duplication of tests or prescriptions ordered
- Improve patient outcomes, like morbidity and mortality
- Standardize care among clinicians, organizations and regions
- Improve clinician productivity
- Speed up access to care and administrative transactions
- Protect privacy and ensure security

In the next section we list the key players in HIT and how they utilize health information technology (adapted from *Crossing the Quality Chasm)*[22]

Patients

- Online searches for health information
- Web portals for storing personal medical information, making appointments, checking lab results, e-visits, etc
- Research choice of physician, hospital or insurance plan
- Online patient surveys
- Online chat, blogs, podcasts, vodcasts and support groups and Web 2.0 social networking
- Personal health records
- Limited access to electronic health records
- Telemedicine and home telemonitoring

Clinicians

- Online searches with MEDLINE, Google and other search engines
- Online resources and digital libraries
- Patient web portals, secure e-mail and e-visits
- Physician web portals
- Clinical decision support, e.g. reminders and alerts
- Electronic health records (EHRs)
- Personal Digital Assistants (PDAs) and smartphones loaded with medical software
- Telemedicine and telehomecare
- Voice recognition software
- Online continuing medical education (CME)
- Electronic (e)-prescribing

- Disease management and registries
- Picture archiving and communication systems (PACS)
- Pay for performance
- Health Information Organizations (HIOs)
- E-research

Nursing and support staff

- Patient enrollment
- Electronic appointments
- Electronic billing process
- EHRs
- Web based credentialing
- Telehomecare monitoring
- Practice management software
- Secure patient-office e-mail communication
- Electronic medication administration record (e-Mar)
- Online educational resources and CME
- Disease registries

Public Health

- Incident reports
- Syndromic surveillance as part of bio-terrorism program
- Establish link to all public health departments (Public Health Information Network)
- Geographic information systems to link disease outbreaks with geography
- Telemedicine
- Remote reporting using mobile technology

Government

- Nationwide Health Information Network
- Financial support for EHR adoption
- Information technology pilot projects and grants
    - Disease management
    - Pay for performance
    - Electronic health records and personal health records
    - Electronic prescribing
    - Telemedicine
    - Broadband adoption

- Health Information Organizations

Medical Educators

- Online medical resources for clinicians, patients and staff
- Online CME
- MEDLINE searches
- Video teleconferencing, web conferencing, podcasts, etc

Insurance Companies

- Electronic claims transmission
- Trend analysis
- Physician profiling
- Information systems for "pay for performance"
- Monitor adherence to clinical guidelines
- Monitor adherence to preferred formularies
- Promote claims based personal health records and information exchanges
- Reduce litigation by improved patient safety through fewer medication errors

Hospitals

- Interoperable electronic health records
- Electronic billing
- Information systems to monitor outcomes, length of stay, disease management, etc
- Bar coding and radio frequency identification (RFID) to track patients, medications, assets, etc
- Wireless technology
- E-intensive care units
- Patient and physician portals
- E-prescribing
- Health Information Organizations (HIOs)
- Telemedicine
- Picture archiving and communication systems (PACS)

Research

- Database creation to study populations, genetics and disease states
- Online collaborative web sites e.g. CaBIG

- Service Oriented Architecture (SOA) initiatives to pull together multiple participants e.g. the National Institute of Health
- Electronic case report forms (eCRFs)
- Software for statistical analysis of data e.g. SPSS
- Literature searches with multiple search engines
- Randomization using software programs
- Improved subject recruitment using EHRs and e-mail
- Online submission of grants

Technology Vendors

- Applying new technology innovations in the field of medicine: hardware, software, genomics, etc
- Data mining
- Interoperability

Organizations involved with HIT

Academic Organizations

Institute of Medicine (IOM). One of the leading organizations in the United States to promote health information technology is the Institute of Medicine. It was established in 1970 by the National Academy of Sciences with the task of evaluating policy relevant to healthcare and providing feedback to the Federal Government. In their two pioneering books *To Error is Human* (1999) and *Crossing the Quality Chasm* (2001), they reported that approximately 98,000 deaths occur yearly due to medical errors. It is their contention that an information technology infrastructure will help the six aims set forth by the IOM: safe, effective, patient centered, timely, efficient and equitable medical care. The infrastructure would support "*efforts to re-engineer care processes, manage the burgeoning clinical knowledge base, coordinate patient care across clinicians and settings over time, support multidisciplinary team functioning and facilitate performance and outcome measurements for improvement and accountability*". They also stress "*the importance of building such an infrastructure to support evidence based practice, including the provision of more organized and reliable information sources on the Internet for both consumers and clinicians and the development and application of decision support tools*".[22, 24]

Two of the IOM's twelve executive recommendations directly relate to information technology:

> <u>Recommendation 7:</u> *"improve access to clinical information and support clinical decision making"*
>
> <u>Recommendation 9:</u> *"Congress, the executive branch, leaders of health care organizations, public and private purchasers and health informatics associations and vendors should make a renewed national commitment to building an information infrastructure to support health care delivery, consumer health, quality measurement and improvement, public accountability, clinical and health services research, and clinical education. This commitment should lead to the elimination of most handwritten clinical data by the end of the decade"*[22]

The IOM cites twelve information technology applications that might narrow the quality chasm. Many of these will be discussed in other chapters:

1. Web based "Personal Health Records"
2. Patient's access to hospital information systems to access their lab and x-ray reports
3. Access to general health information via the Internet
4. Electronic medical records with clinical decision support
5. Pre-visit online histories
6. Inter-hospital data sharing, e.g. lab results (health information exchange)
7. Information to manage populations using patient registries and reminders
8. Patient-physician electronic messaging
9. Online data entry by patients for monitoring, e.g. glucose results
10. Online scheduling
11. Computer assisted telephone triage and assistance (nurse call centers)
12. Online access to clinician or hospital performance data[23]

The Association of American Medical Colleges (AAMC). For more than twenty years the AAMC has been an advocate of incorporating informatics into medical school curricula and promoting medical informatics in general. In their *Better Health 2010 Report* they made the following recommendations:

- Optimize the health and healthcare of individuals and populations through best practice information management
- Enable continuous and life-long performance based learning
- Create tools and resources to support discovery, innovation and dissemination of research results
- Build and operate a robust information environment that simultaneously enables healthcare, fosters learning and advances science[25]

Public-Private Organizations

Bridges to Excellence. This organization consists of employers, physicians, health plans and patients. They currently have four programs incentivized by bonuses:

- Adoption of information technology systems to improve patient care
- Adoption of national guidelines for diabetes care
- Adoption of guidelines for cardiac care
- Adoption of guidelines for spine care[26]

eHealth Initiative. This is a non-profit organization promoting the use of information technology to improve quality and patient safety. Its membership includes virtually all stakeholders involved in the delivery of healthcare. This organization created the "*Connecting Communities for Better Health Program"* that provides seed money to support and connect disparate healthcare communities. They also offer the "*Connecting Communities Toolkit*" that provides guidance how to create and sustain health information organizations. In 2009 they added an extensive section on navigating the ARRA (stimulus package), discussed later in this chapter.[27]

Center for Information Technology Leadership. CITL was chartered in 2002 as a research arm of the Partners Healthcare System in Boston. They make recommendations to other healthcare systems and vendors based on their research. The research areas are: telehealth, diabetes, health information exchanges and ambulatory computerized physician order entry.[28]

Leapfrog. Leapfrog is a consortium of over one hundred and seventy major employers seeking to purchase the highest quality and safest healthcare. Voluntary reporting by hospitals has made hospital comparisons possible and the results are reported on their website. They also have a hospital rewards program to provide incentives to hospitals that show they deliver quality care. One of their patient safety measures is the use of inpatient computerized physician order entry (CPOE) that will be covered in several other chapters.[29]

National Alliance for Health Information Technology. Created in 2002, this non-profit organization is comprised of senior healthcare leaders who work towards a consensus on multiple HIT issues. Members are from prominent healthcare organizations, technology vendors, the Joint Commission and PricewaterhouseCoopers. In 2008 they were funded by the Office of the National Coordinator of Health Information Technology (ONC) to develop definitions for commonly used but controversial terms in HIT such as the electronic medical record. These new definitions will be included in chapters 2 and 4. This group disbanded in August 2009.[30]

Connecting For Health. This organization is a public-private collaboration operated by the Markle Foundation and funded partially by the Robert Wood Johnson Foundation. With over 100 stakeholders, its primary mission is to promote interoperable HIT. They published *Common Framework: Resources for Implementing Private and Secure Health Information Exchange* that helps organizations exchange information in a secure and private manner, with shared policies and technical standards. Using their protocols a tri-state prototype health information exchange was created. The Common Framework with 9 policies guides and 7 technical guides is available free for download on their web site.[31]

The American Health Information Community (AHIC). Secretary Michael Leavitt of the Department of Health and Human Services created the AHIC in 2005. It was a seventeen member advisory board tasked to advance the United State's health IT agenda and make recommendations to the Secretary of HHS. The chair of the AHIC was the Secretary of HHS. Representatives were from government agencies, patient advocacy groups, private employers, insurance companies and the technology industry. They developed "use cases" that described a HIT issue from the end-user perspective. The use cases for 2008 were: remote monitoring, patient-provider secure messaging, personalized healthcare, consultation and transfers of care, public health care case reporting and immunizations and response management. AHIC was dissolved in November 2008 and the NeHC was created and discussed in the next paragraph.[32]

National eHealth Collaborative (NeHC). This government-civilian-consumer collaborative has a board of directors of 18 members and 3 federal liaisons. They are charged with prioritization of HIT standards to promote interoperability. Theoretically, they would create "value cases" and refer those to HITSP for harmonization of standards
and once adopted they would be adopted by the Certification Commission for HIT.[33]

Healthcare Information Technology Standards Panel (HITSP). This panel is a public-private partnership established in 2005 by HHS. It is also sponsored by the American National Standards Institute (ANSI), in cooperation with HIMSS, ATI and Booz Allen Hamilton. HITSP is charged by

the ONC to harmonize standards based on "use cases" derived from AHIC requirements. They work with 170 members and 15 standards development organizations (SDOs) to identify the best standards. The HITSP recommends standards to the Secretary of HHS who accepts them and officially recognizes them one year later after a period of review. Ironically, the private sector is not required to comply with these federal standards, but nevertheless they will likely become the industry-wide standards. Specific standards are available as downloadable pdf documents on the HITSP web site. It should be pointed out that the specifications are system architecture neutral. Each interoperability specification is a suite of documents that provides a roadmap of how standards and specifications will answer the requirements of the use case. For instance, specifics of the standard for using the Continuity of Care Document (CCD) were released as C32 in March 2008 with a detailed explanation of the technical aspects. The CCD is discussed further in chapter 4. The interoperability specifications (ISs) are as follows: (IS 01) EHR lab results reporting; (IS 02) Biosurveillance; (IS 03) Consumer empowerment; (IS 04) Emergency responders EHR; (IS 05) Consumer empowerment and access to clinical information via media; (IS 06) Quality and (IS 07) Medication management.[34]

The Certification Commission for Healthcare Information Technology (CCHIT) was created by HIMSS, AHIMA and Alliance and now includes the American College of Physicians, American Academy of Family Physicians, American Academy of Pediatrics, California HealthCare Foundation, Hospital Corporation of America, McKesson, Sutter Health, United Health Foundation and Wellpoint. Its goals are to: reduce the risk of health information technology (HIT) investment by physicians; ensure interoperability of HIT; enhance the availability of HIT incentives and accelerate the adoption of interoperable HIT. They work with HITSP to adopt standards for EHRs. Their initial step was to certify ambulatory electronic health records. By July 2007 they began evaluating inpatient EHRs and they plan to extend the certification process to Emergency Room and Cardiology EHRs. In 2008 59 ambulatory EHRs were certified. Health Information Organizations (HIOs) were invited to apply for a 2008 Pilot Test. They also anticipate certifying personal health record (PHR) products by 2009. EHRs that have received certification are listed on the web site. Potential EHR purchasers can download the monograph "Concise Guide to Certification" from their web site. The Commission consists of 20 commissioners from a variety of backgrounds and numerous volunteers. Substantial changes have been made to the Commission, in part due to the effect of the ARRA on projected EHR use. In June 2009, after two town hall meetings, CCHIT decided they would offer three different levels of EHR certification so more EHRs would qualify for Medicare or Medicaid reimbursement under ARRA: 1) EHR-C (CCHIT certified® 2011), a comprehensive certification that would actually exceed federal standards. Certification could cost between $37- $50,000 with $5-10,000 yearly. 2) EHR-M or modular or preliminary certification for e-prescribing, PHRs, registries, etc that meet federal standards. Certification standards would likely have to be adjusted to match "meaningful use" criteria, discussed in the chapter on EHRs. This category may appeal to the open-source groups. Projected cost would be in the $5,000-$35,000 range, depending on the number of modules certified 3) EHR-S or site certification would cover self-assembly of non-certified sources and cost $150-$300. Cost of certification will probably still be a contentious issue for small vendors and some believe we will see new certification organizations that will compete with CCHIT.[35-36]

National Committee on Vital and Health Statistics (NCVHS) is a public advisory body to the Secretary of Health and Human Services. It is composed of 18 members from the private sector who are subject matter experts in the fields of health statistics, electronic health information exchange, privacy/security, data standards and epidemiology. They have been very involved in

advising the Secretary in matters related to the Nationwide Health Information Network (NHIN). In January 2008 they forwarded NHIN privacy protection recommendations to the Secretary.[37]

Health Information Security and Privacy Collaborative (HISPC) was established by a research organization that was funded by the Agency for Healthcare Research and Quality. Their goals are to identify best practices and develop solutions for interoperable electronic health information.[38]

Figure 1.3 illustrates the interrelationships between the federal and private sectors that provide input towards the creation of a national health IT infrastructure.

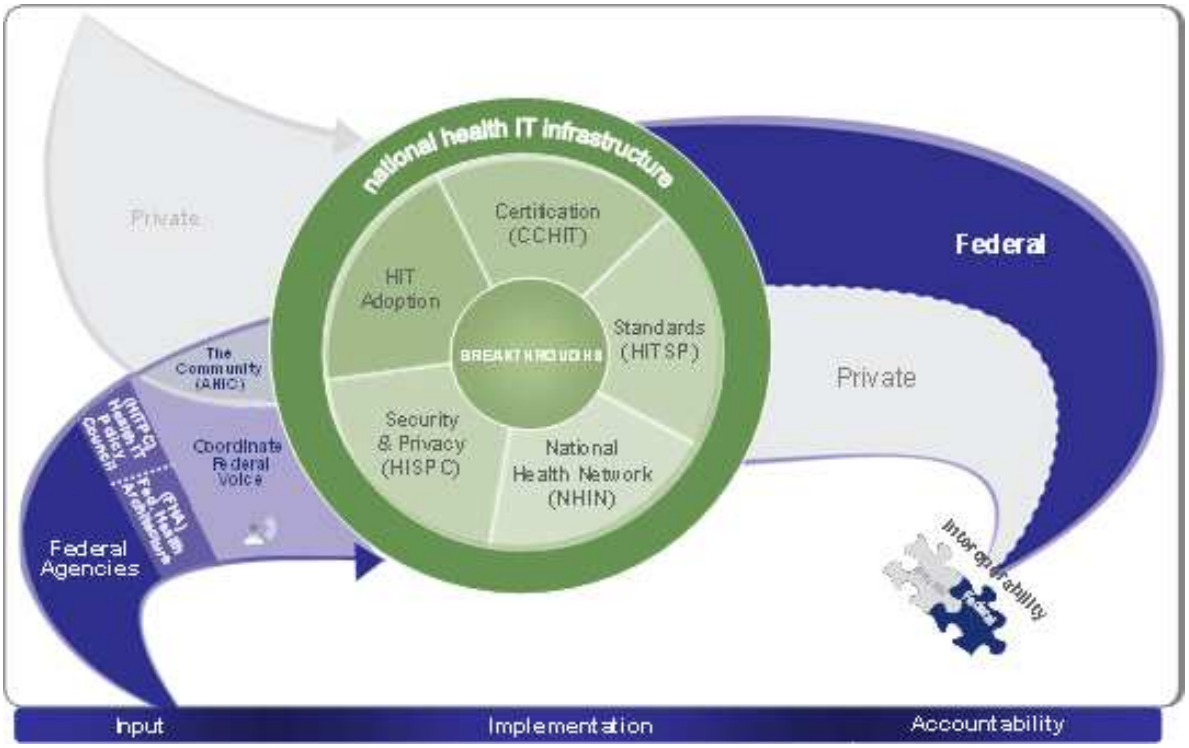

Figure 1.3 The Federal Health Architecture (courtesy ONC)

US Federal Government

The federal government is a major financer of health care with the following programs: Medicare/Medicaid, Veterans Health Administration, Military Health System, Indian Health Service and the Federal Employees Health Benefits Program. It is therefore no surprise that they are heavily involved in health information technology and stand to benefit greatly from an interoperable Nationwide Health Information Network. Agencies such as Medicare/Medicaid and the Agency for Healthcare Research and Quality conduct HIT pilot projects that potentially could improve medical care and/or decrease medical costs.

Before different government agencies are discussed we will outline the new programs included in the 2009 Stimulus Package that impact health information technology.

American Recovery and Reinvestment Act (ARRA). Without a doubt, the most significant governmental change in 2009 that affected HIT has been the ARRA. This legislation will impact HIT adoption, particularly EHRs, as well as training and research. The following is a summary of highlights from the Act that directly affect health information technology:

- Department of Health and Human Services (HHS) Funding
    - $2 billion to the Office of the National Coordinator for HIT (ONC); $300 million to support health information exchanges (see chapter on interoperability); $20 million to National Institute of Standards and Technology (NIST) to develop standards; training and several other options, up to the discretion of the National Coordinator and Secretary of HHS
    - $1.5 billion to Health Resources and Services Administration (HRSA) for HIT system upgrades for public health centers
    - $1.1 billion to AHRQ, NIH and HHS to carry out comparative effectiveness research (CER). The goal is compare treatments, etc and determine the optimal paradigm
- Title XIII Health Information Technology for Economic and Clinical Health (HITECH) Act
    - Provides $17.2 billion reimbursement via Medicare/Medicaid for clinicians and hospitals who adopt electronic health records (EHRs) (details discussed in chapter on EHRs)
    - Establishes a Chief Privacy Officer within ONC
    - Establishes the HIT Policy Committee that makes recommendations to the Coordinator of ONC on issues such as privacy and infrastructure
    - Establishes the HIT Standards Committee that makes recommendations to the Coordinator of ONC on standards that have been developed and harmonized
    - Establish a Health Information Technology Extension Program to assist with HIT training and implementation
    - Create a Health Information Technology Research Center to provide assistance and recognize best practices
    - Secretary of HHS may award State grants for HIT assistance
    - Directs the National Coordinator to report on how HIT impacts health disparities; ONC must have initial HIT (voluntary) standards, implementation specifications and certification criteria by December 31 2009
- Privacy and HIPAA changes—to be discussed in chapter on interoperability
- $4.7 billion for the National Telecommunications and Information Administration's Broadband Technology Opportunities Program
- $2.5 billion for USDA's Distance Learning, Telemedicine and Broadband Program
- $85 million for Indian Health Services HIT programs
- $500 million for Social Security Administration HIT programs
- $50 million for Veterans Affairs (VA) HIT programs
- Establishes Centers for Health Care Information Enterprise Integration to promote HIT innovation
- Provides grants for demonstration projects to develop curricula to educate health professionals about HIT

- Mandates the Secretary of HHS to conduct a study on the impact of open- source electronic health records for "community clinics" and report by October 1 2010
- Provide assistance to universities to create and expand Medical Informatics programs [39-42]

Office of the National Coordinator for Health Information Technology (ONC) is under the Department of Health and Human Services. The most significant goal of the (ONC) is the creation of a universal interoperable electronic health record by the year 2014. To accomplish this goal they are working to harmonize data standards to ensure interoperability and to facilitate health information exchange. The Federal Health Architecture is part of ONC as well as an e-Government Initiative under the Office of Management and Budget, with the goals: provide input from all federal agencies for HIT; provide guidance to federal agencies in regards to coordination of HIT standards and measure accountability. This means they participate and support many of the other HIT related panels and federal agencies that will be discussed in the next paragraphs. In June 2008, ONC released its 5 year Federal HIT Strategic Plan. The plan has two main goals: patient focused health care and population health (promoting electronic health information for public health, biomedical research, quality improvement and emergency preparedness). Each goal has four objectives with the overriding themes of privacy/security, interoperability, adoption and collaborative governance. Strategies and milestones can be found on the ONC web site.[43] Table 1.1 summarizes the goals and objectives of ONC.

Table 1.1 Five year goals and objectives of the Federal HIT Strategic Plan

Goals	Privacy and Security	Interoperability	Adoption	Collaborative Governance
Goal 1 Patient focused Health care	**Objective 1.1** Facilitate electronic exchange, access and use of electronic health information, while protecting the privacy and security of patient's health information	**Objective 1.2** Enable the movement of electronic health information to support patient's health care needs	**Objective 1.3** Promote nationwide deployment of electronic health records and personal health records and other consumer health IT tools	**Objective 1.4** Establish mechanisms for multi-stakeholder priority setting and decision making
Goal 2 Population health	**Objective 2.1** Advance privacy and security policies, principles, procedures and protection for information access in population health	**Objective 2.2** Enable exchange of health information to support population oriented uses	**Objective 2.3** Promote nationwide adoption of technologies to improve population and individual health	**Objective 2.4** Establish coordinated organizational processes supporting information use for population health

In summary, ONC is responsible for coordinating all aspects of health information technology in the United States. They are involved with the adoption, standards harmonization, interoperability, privacy/security and certification of electronic health records. In addition they are coordinating the efforts to create the Nationwide Health Information Exchange (NHIN). They participate with and support multiple private and public health information technology (HIT) initiatives.

In 2009 Dr. David Blumenthal was selected as the National Coordinator by President Obama. A useful list of all federal HIT program web links can be found on the ONC website. The next two committees discussed are part of ONC and were created as part of the ARRA.

Health IT Policy Committee (HITPC). The main goal of this committee is to set priorities regarding what standards are needed for information exchange and establish the policy framework for the development and adoption of national health information exchange. The committee has 20 multi-disciplinary members with the chair being Dr. Blumenthal. They will immediately focus on three working groups: defining what is meant by "meaningful use" of EHRs; the adoption and the certification process of EHRs and information exchange. They will also evaluate 8 HIT areas that require policy and prioritization and these areas are noted in the transcripts from their first meeting posted on their web site.[44]

Health IT Standards Committee (HITSC). This committee will have 23 multi-disciplinary members and be chaired by Jonathan Perlin (HCA). They are tasked to look at standards, implementation specifications and certification criteria for the exchange of health information. They will likely focus on issues that are prioritized by HITPC. They will use the National Institute of Standards and Technology (NIST) to test standards. Both committees will make recommendations to the National Coordinator. They have established 3 working groups: clinical quality, clinical operations and privacy/security. It remains unclear how they will coordinate efforts with the HIT Standards Panel that we will also discuss.[45]

Agency for Healthcare Research and Quality (AHRQ). The AHRQ is an agency under the Department of Health and Human Services. It is "*the lead Federal agency charged with improving the quality, safety, efficiency, and effectiveness of health care for all Americans. As one of 12 agencies within the Department of Health and Human Services, AHRQ supports health services research that will improve the quality of health care and promote evidence based decision making*". This agency sets aside significant grant money to support healthcare information technology (HIT) each year. Since 2004 AHRQ has invested about $280 million in grants to research HIT. The AHRQ also maintains the National Resource Center for HIT and an extensive patient safety and quality section. They also maintain an extensive HIT Knowledge Library with over 6,000 resources.[46]

Centers for Medicare and Medicaid Services (CMS). The CMS also falls under the Department of Health and Human Services. CMS is responsible for providing care to 44 million Medicare and 48 million Medicaid patients (2007 data). In an effort to improve quality and decrease costs, CMS has information technology pilot projects in multiple areas, to include new "pay for performance" demonstration projects that link payments to improved patient outcomes. Several projects will be discussed in later chapters.[47]

Health Resources and Services Administration (HRSA) is part of HHS with the primary mission to assist medical care to the underserved and uninsured in the United States. As noted in the section on the ARRA, HRSA will support grants to support community health centers to include the installation and upgrades of health information technology. They have been a long term supporter of telemedicine and also administer grants in that area. On their site they post a 2008 monograph entitled "*The Underserved and Health Information Technology: Issues and Opportunities"*[48]

State Governments and HIT

There are a variety of state-based HIT initiatives, evaluating the adoption of technologies such as electronic health records and e-prescribing. State Medicaid offices are anxious to conduct pilot projects aimed at reducing costs and/or improving quality of care. The State Alliance for e-Health was created in 2006 in an attempt to navigate the issues of best practices, policies and adoption

obstacles. Support for the Alliance is from ONC as well as a private-public advisory committee. They have three task forces: health information protection, health care practice-health information communication and data exchange taskforces. Their highest priorities are e-prescribing and the privacy and security of health information.[49]

Barriers to Health Information Technology (HIT) Adoption

According to Anderson, the United States is at least 12 years behind many industrialized nations, in terms of HIT adoption. Total investment in 2005 per capita was 43 cents, compared to $21 for Canada, $4.93 for Australia, $21 for Germany and $192 for the United Kingdom.[50] Healthcare organizations tend to spend only 3-4% of their budget on information technology, which is far less than other information dependent industries.[51] Healthcare information technology adoption has multiple barriers listed below and discussed in later chapters:

- **Inadequate time**. This complaint is a common thread that runs throughout most discussions of technology barriers. Busy clinicians complain that they don't have enough time to read, learn new technologies or research vendors. They are also not reimbursed to become technology experts. They usually have to turn to physician champions, local IT support or others for technology advice
- **Cost**. It is estimated that a Nationwide Health Information Network (NHIN) will cost $156 billion dollars over five years and $48 billion annually in operating expenses.[52] Technologies such as picture archiving and communications systems (PACS) and electronic health records are also associated with high price tags. The ARRA will help underwrite the initial purchase of some technologies but long term support will be a different challenge
- **Lack of interoperability**. Electronic health records and the NHIN cannot function until data standards are adopted and implemented nationwide. Interoperability and data standards are covered in more detail in chapter 4.
- **Change in workflow**. Significant changes in workflow will be required to integrate technology into the inpatient and outpatient setting. As an example, clinicians may be accustomed to ordering lab or x-rays by giving a handwritten request to a nurse who actually places the order. Now they have to learn to use computerized physician order entry (CPOE). As with most new technologies, older users have more difficulty changing their habits, even if it will eventually save time or money. According to Dr Carolyn Clancy, the director of AHRQ:

  > *"The main challenges are not technical; it's more about integrating HIT with workflow, making it work for patients and clinicians who don't necessarily think like the computer guys do"*[53]

- **Privacy**. The Health Information Portability and Accountability Act (HIPAA) of 1996 was created initially for the portability, privacy and security of personal health information (PHI) that was largely paper-based. HIPAA regulations were updated in 2009 to better cover the electronic transmission of PHI. This Act has caused healthcare organizations to re-think healthcare information privacy and security. This will be covered in more detail in chapter 4. In the past few years there have been a series of privacy breeches and stolen identities in healthcare organizations, thus adding to the angst
- **Legal.** The Stark and Anti-kickback laws prevent hospital systems from providing or sharing technology such as computers and software with referring physicians.[49] Exceptions

were made to these laws in 2006, as will be pointed out in other chapters. This is particularly important for hospitals in order to share electronic health records and e-prescribing programs with clinician's offices

- **Behavioral change.** Perhaps the most challenging barrier is behavior. In *The Prince* by Machiavelli, it was stated "there is nothing more difficult to be taken in hand, more perilous to conduct, or more uncertain in its success, than to take the lead in the introduction of a new order of things".[54] Dr. Frederick Knoll of Stanford University described the five stages of medical technology acceptance: (1) abject horror, (2) swift denunciation, (3) profound skepticism, (4) clinical evaluation, then, finally (5) acceptance as the standard of care.[55] It is unrealistic to expect all medical personnel to embrace technology. In 1962 Everett Rogers wrote *Diffusion of Innovation*s in which he delineated different categories of acceptance of innovation:
    - the innovators (2.5%) are so motivated they may need to be slowed down
    - early adopters (13.5%) accept the new change and teach others
    - early majority adopters (34%) require some motivation and information from others in order to adopt
    - the late majority (34%) require encouragement to get them to eventually accept the innovation
    - laggards (16%) require removal of all barriers and often require a direct order [56]

  It is important to realize, therefore, that at least 50% of medical personnel will be slow to accept any information technology innovations and they will be perceived as dragging their feet or being "Luddites". With declining reimbursement and emphasis on increased productivity, clinicians have a natural and sometimes healthy dose of skepticism. They dread widespread implementation of anything new unless they feel certain it will make their lives or the lives of their patients better. In this situation, selecting clinical champions and conducting intensive training are critical to implementation

- **Inadequate workforce**. As pointed out by Dr. William Hersh of the Oregon Health and Science University, there is a need for a work force capable of leading implementation of the electronic health record and other technologies.[57] The first Work Force for Health Information Transformation Strategy Summit, hosted by the American Medical Informatics Association (AMIA) and the American Health Information Management Association (AHIMA) made several strategic recommendations regarding how to improve the work force.[58] The American Medical Informatics Association has been the leader in attempting to increase the workforce of information technology workers with its *AMIA 10x10 Program*.[59] Clearly, with the new influx of federal government support from the stimulus package there is a great need for health informaticians. According to Dr. Detmer, president and chief executive of the American Medical Informatics Association, he estimates that about 70,000 health informaticians will be needed for the expansion of HIT in the United States.[60]

  In addition to skilled informaticians, we will need to educate residents in training and faculty at medical schools, given the rapidly changing nature of HIT. The APA Summit on Medical Student Education Task Force on Informatics and Technology recommended that instead of CME, we need "longitudinal, skills-based tutoring by informaticians".[61] Family Medicine residency programs are generally ahead of other specialty training programs in regards to IT training. They also recommend a longitudinal approach to IT competencies.[62]

- **Health Information Technology: Hype versus Fact.** The Gartner Group described 5 phases of the hype-cycle that detail the progression of technology from the "technology trigger" to the "peak of inflated expectations" to the "trough of disillusionment" to the "slope of enlightenment" to the "plateau of productivity".[63] As already noted, clinicians tend to be leery about new technologies that promise a lot, but deliver little. As a rule, if technology doesn't save time or money physicians are not interested. Shcherbatykh points out that informatics studies are difficult to conduct, particularly the gold standard: prospective, double-blinded, randomized controlled trials. He lists 10 recommendations to conduct better health informatics trials.[64]

  Be wary of vendors who promise the world and medical experts who are also consultants for IT companies. Additionally, there is a paucity of high quality studies that address the effects of information technology on cost and true patient outcomes. Several investigators have also pointed out the fact that a majority of studies have been published by only a few medical centers with a long standing history of HIT implementation. A 2009 review of the costs and benefits of HIT was reported in the journal *Health Affairs*. They reviewed 182 studies that covered the topics of health IT leaders, commercial health IT systems, standalone applications, implementation facilitators and barriers and cost and cost-effectiveness. They concluded that a) there were many new patient-focused applications reported, but little serious evaluation b) twenty percent of articles came from the same IT leaders. They found increasing articles on commercial off the shelf (COTS) applications but a lack of useful articles about implementation at a variety of settings c) a lack of "meaningful data on the cost-benefit calculations of actual IT implementation". They posit that better proof would result in better adoption.[65]

  Both the RAND Corporation and the Center for Information Technology Leadership reported in 2005 that HIT would save the US about $80 billion annually.[66, 28] The Congressional Budget Office (CBO), on the other hand, refuted this optimistic viewpoint in May 2008. They published a monograph entitled *Evidence on the Costs and Benefits of Health Information Technology* that reviews the evidence on the adoption and benefits of HIT, the costs of implementing, possible factors to explain the low adoption rate and the role of the federal government in implementing HIT. The bottom line for the CBO is that "*By itself, the adoption of more health IT is generally not sufficient to produce significant cost savings. "* A concern emanating from this report is the CBO position that penalties and not subsidies are more likely to force HIT adoption.[67]

  There are a significant number of healthcare consultants that don't believe that greater HIT adoption will result in significant cost savings, in spite of supporting these newer technologies.[68] Importantly, Carol Diamond of the Markle Foundation points out that HIT success can't be measured by the number of hospitals that have adopted EHRs but instead whether patient outcomes improve.[69]

Medical Informatics Programs

One of the best sites to review the various Medical Informatics programs in the United States and overseas can be found on the American Medical Informatics Association's web site. Another excellent site for listing available Medical Informatics programs in the United States and the United Kingdom is the Biohealthmatics web site. Medical Informatics programs can be degree, certificate, fellowship and short courses. Most programs are part of a medical or nursing school and others may be part of a health related organization such as the National Library of Medicine. Courses can be

online or taught in a classroom setting. Medical Informatics degree programs are available as follows: associate degree, undergraduate degree, Master's degree, PhD degree or part of another degree program. The following table was extracted (June 2009) from information posted on the AMIA site. This will give the reader an idea of how many programs are available in North America and in which category. In addition, it will provide an idea as to the rapid growth of Medical Informatics programs in a relatively short period of time. [70-71]

Table 1.2 Medical Informatics programs listed on the AMIA web site

Program type	Number of programs	
	2008	2009
Associate degree	1	1
Undergraduate degree	5	8
Masters degree	65	69
PhD degree	26	31
Certificate	36	38
Short courses	13	13
Online courses	28	32
10x10 programs	3	10

Medical Informatics Organizations

The following organizations are considered among the most important and influential in health information technology:

American Medical Informatics Association (AMIA)

- Founded in 1990 by the merger of the American Association for Medical Systems and Informatics, the American College of Medical Informatics and the Symposium on computer Applications in Medical Care
- As of 2009 has greater than 4000 members from clinical, technical and research sectors
- Members are from 65 countries
- Web site includes job exchange, academic programs, fellowships, grants, and an e-newsletter
- Membership includes subscription to the Journal of the American Medical Informatics Association
- Opportunity to join a working group to discuss issues and formulate white papers
- Annual national symposium in the fall as well as a spring Congress [70]

Healthcare Information and Management Systems Society (HIMSS)

- Founded in 1961
- As of 2007 has over 20,000 members
- 300 corporations are members

- Annual symposium with more than 20,000 attendees
- Professional certification
- Educational publications, books and CD-ROMs
- Web conferences on Medical Informatics topics
- Surveys on multiple topics [72]

American Health Information Management Association (AHIMA)

- Founded in 1928
- As of 2009 has more than 53,000 members
- It began as a medical records association but now includes any healthcare worker involved in information management
- "*AHIMA supports the common goal of applying modern technology to and advancing best practices in health information management*"
- AHIMA web site has an excellent section on personal health records
- AHIMA journal is available on their web site at no cost [58]

Alliance for Nursing Informatics (ANI)

- Combines 25 separate nursing informatics organizations
- As of 2007 has more than 3,000 members
- Sponsored by both the AMIA and HIMSS
- Provides a collaborative group for consensus about nursing informatics [73]

Medical Informatics Careers

The timing is excellent for a career in Medical Informatics. With the emphasis on a Nationwide Healthcare Information Network and electronic health records, hospitals and vendors will be looking for healthcare workers who are knowledgeable in both technology and medicine. The Department of Labor estimates that there will be 4% growth in the demand for trained health informatics specialist in multiple areas in the private, federal and military sectors. Informaticians will be needed for design, training, implementation and governance of the many new technologies arriving on the medical scene. It is anticipated that government reimbursement for EHRs will only increase the need for skilled HIT workers. The Biohealthmatics, HIMSS, American Nurse Informatics, Health IT News and the AMIA web sites list multiple interesting healthcare IT jobs. Examples include nurse and physician informaticists, systems analysts, information directors, chief information officers (CIOs) and chief medical information officers (CMIOs).[70-74] Recruiting organizations also maintain multiple listings for healthcare IT jobs.

The American Medical Informatics Association is in the process of establishing the medical subspecialty of *clinical informatics*. It is likely that it will take several years to have this new specialty approved by the American Board of Medical Specialties. In the March/April issue of the JAMIA, the core content for this new specialty is spelled out.[75]

Although physicians can become chief medical information officers in very large organizations, the reality is that nurses have the greatest potential to be involved with IT training and

implementation at the average hospital or large clinic. Larger, more urban clinics may have the luxury of inhouse IT staff, unlike smaller and more rural practices. Of note is the fact that the field of nursing already has an informatics specialty certification. Nurse informaticists today are likely to help implement IT initiatives such as EHRs, bar coding and e-prescribing. We believe that nurses are best positioned to assist with future IT initiatives and have the greatest need for formal training. A 2007 HIMSS Nursing Informatics Survey (776 respondents) revealed some interesting statistics about today's nurse informaticists:

- 33% have 10 years in the specialty
- 57% are involved with EHRs
- 54% work in a hospital setting
- 48% have at least 16 years of clinical nursing experience
- 34% have formal IT training; most receive on the job training
- 74% do not continue clinical duties after the transition to their IT position
- The average salary was $83,675 [76]

Medical Informatics Resources

Because of the rapidly changing nature of technology it is difficult to find resources that are current. It is also difficult to find resources that are not overly technical that would be appropriate for the Medical Informatics neophyte. There are numerous excellent journals, e-journals and e-newsletters that contain articles that discuss important aspects of health information technology. Because Medical Informatics is gaining popularity in the field of medicine many excellent articles can also be found in major medical journals that do not normally focus on technology. As an example, many excellent articles on informatics and healthcare policy appear in *Health Affairs*, a bimonthly journal that features web exclusives, blogs and e-newsletters.[77] Furthermore, several informatics-related web sites link to the major national and international Medical Informatics print and online journals.[78-81]

Journals:

- *Journal of the American Medical Informatics Association* is the bimonthly journal of the AMIA. It features peer reviewed articles that run the gamut from theoretical models to practical solutions. The journal is included in the AMIA membership and is most appropriate for medical and IT professionals.[82]
- *International Journal of Medical Informatics* is an international monthly journal that covers information systems, decision support, computerized educational programs and articles aimed at healthcare organizations. In addition to standard articles, they publish short technical articles and reviews.[83]
- *CIN: Computers, Informatics, Nursing* is a bimonthly print journal targeting the nursing professional. Also offers PDA downloads, RSS feeds and a newsletter.[84]

E-journals:

- *Informatics Review* is the biweekly publication of the Association of Medical Directors of Information Systems and the Improve-IT Institute. They publish concise reviews of clinical

informatics articles published in six major medical journals. Dean Sittig PhD is the editor of this very helpful resource. It is also available as an e-mail newsletter, a RSS feed and a downloadable program for mobile platforms using Avantgo. Last issued published was September 2008.[85]

- *BMC Medical Informatics and Decision Making* is an open-access free online journal publishing peer-reviewed research articles. This journal is part of BioMed Central, an online publisher of 188 online free full text journals. Because it is an open-access model it allows for much more rapid review and publication, a plus for informatics journals.[86]
- *The Open Medical Informatics Journal* is another open-access free online journal that publishes Medical Informatics research articles and reviews. Bentham Science publishes 89 online and print journals as well as 200 online open-access journals. An abstract is available online and the full text pdf copy is downloadable.[87]
- *Journal of Medical Internet Research* is an independent open-access online journal that publishes articles related to medicine and the Internet. The articles are free to read in an html format but there is a cost to download articles in a pdf format or to become a member.[88]

E-newsletters:

- *iHealthBeat* is a free daily e-mail newsletter on health information technology published as a courtesy by the California Healthcare Foundation. It is also available through RSS feeds, Twitter and they offer frequent podcasts.[89]
- *HealthCareITNews* is available as a daily online, RSS feed or print journal. It is published in partnership with HIMSS and reviews broad topics in HIT. They also publish the online e-journals *NHINWatch*, *MobileHealthWatch* and *Health IT Blog.*[90]
- *eHealth SmartBrief* is a free newsletter e-mailed three times weekly. In addition to broad coverage of HIT, they offer RSS feeds, blogs, reader polls and job postings.[91]
- *Health Data Management* offers a free daily e-newsletter, in addition to their comprehensive web site. The web site offers 20 channels or categories of IT information, webinars, whitepapers, podcasts and RSS feeds.[92]

Online Resource Sites:

- *University of West Florida Medical Informatics Program Resource Site* augments this book with valuable web links organized in a similar manner as the book chapters. It also includes links to excellent informatics newsletters and journals.[93]
- *Agency for Healthcare Research and Quality Knowledge Library is* another excellent resource with over 6,000 articles and other resources that discuss health information technology related issues.[94]

Key Points

- Medical Informatics is new enough that many definitions are still evolving
- Health information technology (HIT) holds promise for improving healthcare quality, reducing costs and expediting the exchange of information
- Private, Academic and Federal organizations are key players in HIT
- The US Government has the goal of a universal electronic health record for all Americans that is interoperable with other systems. The 2009 HITECH Act may play a major role
- Barriers to widespread adoption of HIT include: time, cost, privacy, change in workflow, legal, behavioral barriers and lack of high quality studies proving the benefits
- Many new degree and certificate programs are available to prepare for careers in Medical Informatics

Conclusion

Medical Informatics is a new, exciting and evolving field. New specialties and careers are now possible. In spite of its importance and popularity, significant obstacles remain. The expectation is that information technology will improve medical quality, patient safety, educational resources and patient-physician communication, while decreasing cost. Although technology holds great promise, it is not the solution for every problem facing medicine today. As noted by Dr. Safron of the American Medical Informatics Association "*technology is not the destination, it is the transportation*".[70] Research in Medical Informatics is being published at an increasing rate so hopefully new technologies will be evaluated more often and more objectively. Better studies are needed to demonstrate the effects of health information technology on actual patient outcomes and return on investment, rather than studies based on surveys and expert opinion.

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2

Electronic Health Records

ROBERT E HOYT

Learning Objectives

- After reading this chapter the reader should be able to:
- State the definition and history of electronic health records
- Describe the limitations of paper based health records
- Identify the benefits of electronic health records
- List the key components of an electronic health record
- Describe the 2009 Medicare and Medicaid reimbursement for electronic health records
- Describe the benefits of computerized order entry and clinical decision support systems
- State the obstacles to purchasing and implementing an electronic health record

"If computers get too powerful, we can organize them into a committee.
That will do them in"
Bradley's Bromide

There is no topic in Medical Informatics as important, yet controversial, as the electronic health record (EHR). That is the reason EHRs are discussed in the second chapter. The history of EHRs in the United States is relatively short. The Problem Oriented Medical Information System (PROMIS) was developed by The Medical Center Hospital of Vermont in collaboration with Dr. Lawrence Weed, the originator of the problem oriented record and SOAP formatted notes. Ironically, the inflexibility of the concept led to its demise.[1] In a similar time frame the American Rheumatism Association Medical Information System (ARAMIS) appeared. All findings were displayed as a flow sheet. The goal was to use the data to improve the care of rheumatologic conditions.[2] Other EHR systems began to appear throughout the US: the Regenstrief Medical Record System (RMRS) developed at Wishard Memorial Hospital, Indianapolis; the Summary Time Oriented Record (STOR) developed by the University of California, San Francisco; HELP developed at the Latter Day Saints Hospital, Salt Lake City and The Medical Record developed at Duke University.[3]

In 1970 Schwartz optimistically predicted "*clinical computing would be common in the not too distant future*".[4] In 1991 the Institute of Medicine (IOM) recommended electronic health records as a solution for many of the problems facing modern medicine.[5] Since the IOM recommendation, little progress has been made during the last decade for multiple reasons. As Dr. Donald Simborg states, the slow acceptance of electronic health records is like the "*wave that never breaks*".[6]

In this chapter we will primarily discuss outpatient (ambulatory) electronic health records. Inpatient EHRs share many similarities to ambulatory EHRs but the scope, price and complexity are different.

Electronic Health Record Adoption

Outpatient (Ambulatory) EHR Adoption: The adoption rate of ambulatory EHRs has been reported to be in the 10-20% range, depending on which study you read and what group is studied.[7]

Many of the commonly quoted statistics come from surveys, with their obvious shortcomings. It is also important to realize that many outpatient practices may have EHRs but continue to run dual paper and electronic systems or may use only part of the EHR. It should also be noted that EHRs are being purchased largely by primary care practices, as opposed to surgical specialties, which may skew the statistics. Furthermore, a significant concern is that small and/or rural practices are more likely to lack the finances and information technology support to purchase and implement EHRs.

In 2006, The National Ambulatory Medical Care Survey, conducted by the Centers for Disease Control reported that 29% of respondents had a partial EHR but only 12% had a truly comprehensive EHR. A comprehensive EHR was defined as having computerized ordering of medication, test ordering, test results retrieval and clinical notes.[8] In July 2008 the New England Journal of Medicine (NEJM) reported the adoption rate of outpatient EHRs. In this study a sample of 5000 physicians was selected from the AMA master file. Osteopaths, residents and federal physicians were excluded. The return rate of the survey was just over 60%. The most significant finding was that only 4% of respondents reported using a comprehensive EHR (order entry capability and decision support), whereas 13% reported using a basic EHR system. As has been reported before, the adoption rate was higher for large medical groups or medical centers. Given the fact that most experts believe only comprehensive EHRs will impact patient safety and improve the quality of medical care, the 4% adoption rate is disturbing. It is also possible that those respondents who actually returned the survey were more likely to be technology adopters; therefore the 4% figure could be high. Importantly, responding physicians did report multiple beneficial effects of using EHRs.[9]

Inpatient EHR Adoption: The American Hospital Association reported on the 2006 use of EHRs with more than 1,500 community hospitals responding. They noted that 68% of the hospitals surveyed had implemented inpatient EHRs, but only 11% were fully implemented and these were mainly by large urban and/or teaching hospitals. In only 10% were physicians using computerized physician order entry (CPOE) to order medications, at least 50% of the time.[10]

In March 2009 an article about inpatient EHR adoption appeared in the New England Journal of Medicine by the same authors of the ambulatory NEJM study cited above. Of interest, both NEJM articles were co-authored by Dr. David Blumenthal, the new National Coordinator for Health Information Technology. They surveyed all members of the American Hospital Association and had a return rate of 63% (3049 hospitals). Their results showed that 7.6% of the respondents reported a basic EHR system and only 1.5% reported a comprehensive EHR. Again, large urban and/or academic centers had the highest adoption rates. User satisfaction rates were not reported.[11]
A HIMSS Analytics study looked at data from over 5000 hospitals to determine the actual level or degree of EHR adoption in 2008. The scale they used rated hospitals from 0, meaning hospitals with an EHR with no functionality installed, to 7 indicating a fully functional paperless system. As of March 2009, only two hospital systems in the US had attained level 7 adoption.[12] (Table 2.1)

One can only speculate why the medical profession has been willing to tolerate the lack of legible and accessible information for so many years. Many physicians believe that purchasing an EHR is not their responsibility and therefore someone else should pick up the tab. Others are concerned that they will purchase the wrong system and waste money and others are simply overwhelmed with the task of implementing and training for a completely different system. As a group, physicians are not noted for embracing innovation. In their defense, new technologies should be shown to improve patient care, save time or money, in order to be accepted.

There are over three hundred EHR vendors but only about ten to twenty seem to be consistently successful in terms of a large client base. If the selection and purchase of EHRs was easy they would already be universal. As you will see later in this chapter, there are issues such as

implementation and training that are just as important as the decision which EHR to purchase.

Table 2.1 EHR adoption statistics by stage (courtesy HIMSS Analytics)

Stage	Cumulative Capabilities	2008
7	Paperless system. Able to generate Continuity of Care Document (CCD). Data warehousing in use	0.3%
6	Physician documentation (structured templates), full CDSS and CPOE, full PACS	0.5%
5	Closed loop medication administration	2.5%
4	Computerized Physician Order Entry (CPOE) and CDSS	2.5%
3	Clinical documentation (flow sheets), CDDS, PACS available outside radiology	35.7%
2	Clinical data repository (CDR), Clinical decision support system (CDDS), Document imaging	31.4%
1	Lab, radiology and pharmacy modules installed	11.5%
0	Lab, radiology and pharmacy modules not installed	15.6%

The United States is not the only country to face the challenge of trying to have a nationwide interoperable electronic health record. Canada plans a universal EHR by 2009, Australia by 2010 and Great Britain by 2014, although delays have almost universally been reported.[13] According to a 2000 Harris Interactive study, Sweden, Germany, Great Britain and Denmark are considerably ahead of the United States in terms of general practitioners using electronic health records.[14] Importantly, because these countries are smaller and may use only one EHR, it will be much easier to develop a national plan for EHRs and a national health information network.

The Stimulus Package and EHR Reimbursement

Arguably, the most significant EHR-related initiative occurred in 2009 as part of the American Recovery and Reinvestment Act (ARRA). Specifically, $19 billion was dedicated for Medicare and Medicaid reimbursement for EHRs to clinicians and hospitals. In order to be reimbursed there must be "meaningful use" that, at a minimum, means that an EHR:

- Must include e-prescribing
- Provides the electronic exchange of information (interoperability)
- Is capable of producing quality reports
- Must be certified (presumably by CCHIT)

As of mid-2009 an exact definition of meaningful use has not been published and a final definition is promised by December 31 2009, followed by 60 days for comments. Tables 2.2-2.3 list the Medicare and Medicaid reimbursement levels for EHRs. Clinicians may earn even more (an additional 10%) if they practice in a disadvantaged or underserved area. Hospitals and physicians who do not have "meaningful" EHR use will receive penalties of 1% in 2015, 2% in 2016 and 3% in 2017. Penalties could reach 5% in 2018 and beyond if fewer than 75% of physicians are using EHRs at that point. It is currently assumed that CCHIT will be the certification body for EHRs under the new reimbursement program. Physicians can not be reimbursed by both Medicare and Medicaid.

Table 2.2 Medicare reimbursement for EHR adoption

Year	2011 (year 1)	2012 (year 1)	2013 (year 1)	2014 (year 1)	2015 (year 1)
2011	$18,000				
2012	$12,000	$18,000			
2013	$8,000	$12,000	$15,000		
2014	$4,000	$8,000	$12,000	$15,000	
2015	$2,000	$4,000	$8,000	$12,000	$0
2016	$0	$2,000	$4,000	$8,000	$0
Total	**$44,000**	**$44,000**	**$42,000**	**$35,000**	**$0**

Table 2.3 Medicaid reimbursement for EHR adoption

Eligible Clinician	Reimbursement Amount
Independent physician	$25,000 for purchase, $10,000 for ops/maintenance Max of $65,000 over 5 years
Pediatrician	$16,667 for purchase, $6,667 for ops/maintenance Max of $51,200 over 5 years
Nurse mid-wife	$25,000 for purchase, $10,000 for ops/maintenance Max of $64,000 over 5 years
Physician assistant	To be determined by Sec. HHS
Nurse practitioner	$25,000 for purchase, $10,000 for ops/maintenance Max of $64,000 over 5 years

Hospitals can also be reimbursed for the purchase of EHRs and can share this technology with the known limits of the "safe harbor act" discussed later in this chapter. Hospitals will start at a base of $2 million annually with decreasing amounts over five years, plus an additional amount dependent on patient volume.[15]

If clinicians purchase an EHR in 2009 they are eligible for a 2% bonus for electronic prescribing, as discussed in the chapter on e-prescribing and another 2% bonus if they participate in the Physician Quality Reporting Initiative, discussed in the chapter on pay for performance.

Definition of the term Electronic Health Record

There is no universally accepted definition of an EHR. As more functionality is added the definition will need to be broadened. Importantly, EHRs are also known as electronic medical records (EMRs), computerized medical records (CMRs), electronic clinical information systems (ECIS) and computerized patient records (CPRs). Throughout this book we will use electronic health record as the more accepted and inclusive term, but either term is acceptable.

Figure 2.1 demonstrates the relationship between EHRs, EMRs and personal health records (PHRs).[16]

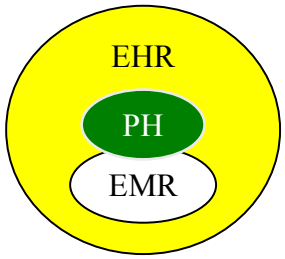


Figure 2.1 Relationship between EHR (electronic health record), PHR (personal health record) and EMR (electronic medical record)

The consensus is that:

- The EHR is the larger system that includes the EMR and PHR and interfaces with multiple other electronic systems locally, regionally and nationally
- The EMR, on the other hand, is the electronic patient record located in an office or hospital
- The PHR is a collection of health information by and for the patient. There is overlap between the EMR and the PHR, since the PHR can be part of the EMR as will be pointed out in the chapter on patient informatics

In May 2008 the National Alliance for Health Information Technology released the following definitions in an effort to standardize terms used in HIT:

Electronic Medical Record: "*An electronic record of health-related information on an individual that can be created, gathered, managed and consulted by authorized clinicians and staff within one healthcare organization*".

Electronic Health Record: "*An electronic record of health-related information on an individual that conforms to nationally recognized interoperability standards and that can be created, managed and consulted by authorized clinicians and staff across more than one healthcare organization*".

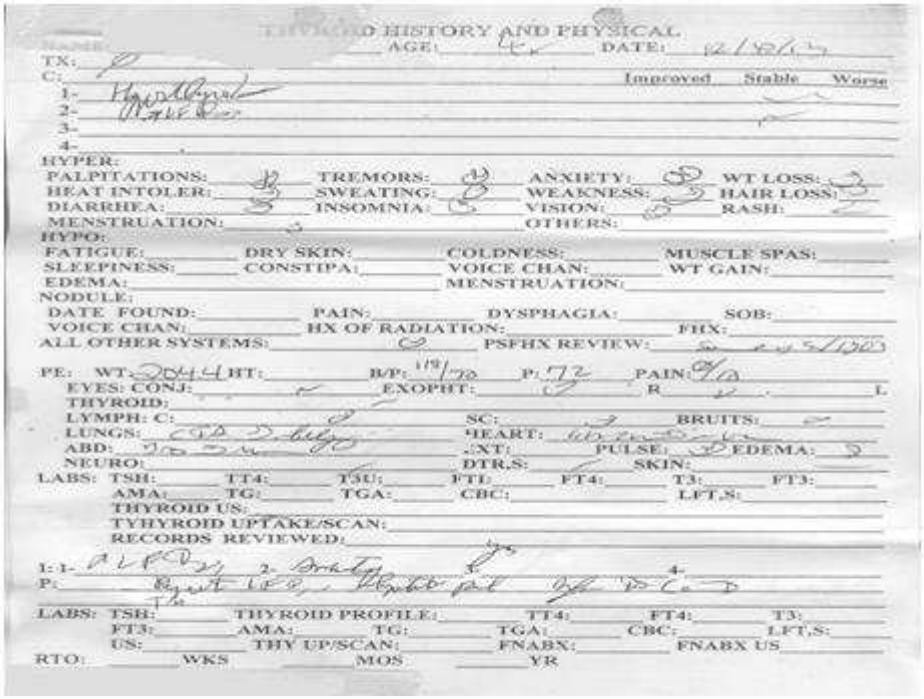
Personal Health Record: "*An electronic record of health-related information on an individual that conforms to nationally recognized interoperability standards and that can be drawn from multiple sources while being managed, shared and controlled by the individual*".[17]

Why do we need Electronic Health Records?

The following are the most significant reasons why our healthcare system would benefit from the widespread transition from paper to electronic health records.

- **The paper record is severely limited**. Much of what can be said about handwritten prescriptions can also be said about handwritten office notes. Figure 2.2 illustrates the problems with a paper record. In spite of the fact that this clinician used a template, the handwriting is illegible and the document cannot be electronically shared or stored. It is not structured data that is computable and hence sharable with other computers and systems. Other shortcomings of paper: expensive to copy, transport and store; easy to destroy; difficult to analyze and determine who has seen it; and the negative impact on the environment. Electronic patient encounters represent a quantum leap forward in legibility and the ability to rapidly retrieve information. Almost every industry is now computerized and digitized for rapid data retrieval and trend analysis. Look at the stock market or companies like Walmart or Federal Express. Why not the field of medicine?

  With the relatively recent advent of "pay for performance" there is a new reason to embrace technology in order to receive more reimbursement. It is much easier to retrieve and track patient data using EHRs and patient registries than to use labor intensive paper chart reviews. EHRs are much better organized than paper charts, allowing for faster retrieval of lab or x-ray results. It is also likely that EHRs will have an electronic problem summary list that outlines a patient's major illnesses, surgeries, allergies and medications. How many times does a physician open a large paper chart, only to have loose lab results fall out? How many times does a physician re-order a test because the results or the chart is missing? It is important to note that paper charts are missing as much as 25% of the time, according to one study.[18] Even if the chart is available; specifics are missing in 13.6% of


HISTORY AND PHYSICAL

AGE: DATE:

TX:

C: Improved Stable Worse

1-

2-

3-

4-

HYPER:

PALPITATIONS: TREMORS: ANXIETY: WT LOSS:

HEAT INTOLER: SWEATING: WEAKNESS: HAIR LOSS:

DIARRHEA: INSOMNIA: VISION: RASH:

MENSTRUATION: OTHERS:

HYPO:

FATIGUE: DRY SKIN: COLDNESS: MUSCLE SPAS:

SLEEPINESS: CONSTIPA: VOICE CHAN: WT GAIN:

EDEMA: MENSTRUATION:

NODULE:

DATE FOUND: PAIN: DYSPHAGIA: SOB:

VOICE CHAN: HX OF RADIATION: FHX:

ALL OTHER SYSTEMS: PSFHX REVIEW:

PE: WT: HT: BP: P: PAIN:

EYES: CONJ: EXOPHT: R L

THYROID:

LYMPH: C: SC: BRUITS:

LUNGS: HEART:

ABD: XT: PULSE: EDEMA:

NEURO: DTR,S: SKIN:

LABS: TSH: TT4: T3U: FTI: FT4: T3: FT3:

AMA: TG: TGA: CBC: LFT,S:

THYROID US:

TYHYROID UPTAKE/SCAN:

RECORDS REVIEWED:

I: 1- 2- 4-

P:

LABS: TSH: THYROID PROFILE: TT4: FT4: T3:

FT3: AMA: TG: TGA: CBC: LFT,S:

US: THY UP/SCAN: FNABX: FNABX US

RTO: WKS MOS YR

Figure 2.2 Outpatient paper-based patient encounter form

With the relatively recent advent of "pay for performance" there is a new reason to embrace technology in order to receive more reimbursement. It is much easier to retrieve and track patient data using EHRs and patient registries than to use labor intensive paper chart reviews. EHRs are much better organized than paper charts, allowing for faster retrieval of lab or x-ray results. It is also likely that EHRs will have an electronic problem summary list that outlines a patient's major illnesses, surgeries, allergies and medications. How many times does a physician open a large paper chart, only to have loose lab results fall out? How many times does a physician re-order a test because the results or the chart is missing? It is important to note that paper charts are missing as much as 25% of the time, according to one study.[18] Even if the chart is available; specifics are missing in 13.6% of patient encounters according to another study. Table 2.4 shows the types of missing information and its frequency.[19] According to the President's Information Technology Advisory Committee, 20% of laboratory tests are re-ordered because previous studies are not accessible.[20] This statistic has great patient safety, productivity and financial implications.

Table 2.4 Types and frequencies of missing information

Information Missing During Patient Visits	% Visits
Lab results	45%
Letters/dictations	39%
Radiology results	28%
History and physical exams	27%
Pathology results	15%

EHRs allow easy navigation through the entire medical history of a patient. Instead of asking to "pull paper chart volume 1 of 3" to search for a lab result, it is simply a matter of a few mouse clicks. Another important advantage is the fact that the record is available 24 hours a day, 7 days a week and doesn't require an employee to pull the chart, nor extra space to store it. Adoption of electronic health records has saved money by decreasing full time equivalents (FTEs) and converting records rooms into more productive space, such as exam rooms. Importantly, electronic health records are accessible to multiple healthcare workers at the same time, at multiple locations. While a billing clerk is looking at the electronic chart, the primary care physician and a specialist can be analyzing clinical information simultaneously. Moreover, patient information should be available to physicians on call so they can review records on patients who are not in their panel. Furthermore, it is believed that electronic health records improve the level of coding. Do clinicians routinely submit a lower level of care for billing purposes because they know that handwritten patient notes are short and incomplete? Templates may help remind clinicians to add more history or details of the physical exam, thus justifying a higher level of coding (Templates are disease specific electronic forms that essentially allow you to point and click a history and physical exam). A study of the impact of an EHR on the completeness of clinical histories in a labor and delivery unit demonstrated improved documentation, compared to prior paper-based histories.[21] Lastly, EHRs provide clinical decision support such as alerts and reminders, which we will cover later in this chapter.

- **The need for improved efficiency and productivity**. The goal is to have patient information available to anyone who needs it, when they need it and where they need it. With an EHR, lab results can be retrieved much more rapidly, thus saving time and money. It should be pointed out however, that reducing duplicated tests benefits the payers and patients and not clinicians so there is a misalignment of incentives. Moreover, a study in 1987 using computerized order entry showed that simply displaying past results reduced duplication and the cost of testing by only 13%. [22] If lab or x-ray results are frequently missing, the implication is that they need to be repeated which adds to this country's staggering healthcare bill. The same could be said for duplicate prescriptions. It is estimated that 31% of the United State's $2.3 trillion dollar healthcare bill is for administration.[23] EHRs are more efficient because they reduce redundant paperwork and have the capability of interfacing with a billing program that submits claims electronically. Consider what it takes to simply get the results of a lab test back to a patient using the old system. This might involve a front office clerk, a nurse and a physician. The end result is frequently placing the patient on hold or playing "telephone tag". With an EHR, lab results can be forwarded via secure messaging. Electronic health records can help with productivity if templates are used judiciously. As noted, they allow for point and click histories and physical exams, thus saving time. Embedded educational content for clinicians is one of the newest features of a comprehensive EHR. Clinical practice guidelines, linked educational content and patient handouts can be part of the EHR. This may permit finding the answer to a medical question while the patient is still in the exam room. Several EHR companies also offer a centralized area for all physician approvals and signatures of lab work, prescriptions, etc. This should improve work flow by avoiding the need to pull multiple charts or enter multiple EHR modules.
- **Quality of care and patient safety**. As we have previously suggested, an EHR should improve patient safety through many mechanisms: (a) Improved legibility of clinical notes (b) Improved access anytime and anywhere (c) Reduced duplication (d) Reminders that tests or preventive services are overdue (e) Clinical decision support that reminds us of patient

allergies, the correct dosage of drugs, etc. (f) Electronic problem summary lists provide diagnoses, allergies and surgeries at a glance. In spite of the before mentioned benefits, a study by Garrido of quality process measures before and after implementation of a widespread EHR in the Kaiser-Permanente system, failed to show improvement.[24] To date there has only been one study published that suggested use of an EHR decreased mortality. This particular EHR had a disease management module designed specifically for renal dialysis patients that could provide more specific medical guidelines and better data mining to potentially improve medical care. The study suggested that mortality was lower compared to a pre-implementation period and compared to a national renal dialysis registry. Unfortunately, the lead author was also the founder of the company that sells the software.[25] As pointed out by Wears and Berg, "*systems cannot be adequately evaluated by their developers*", not to mention the conflict of interest.[26]

Large healthcare organizations can now easily analyze patient data to improve quality and patient safety. Based on its own internal data, the healthcare organization Kaiser-Permanente determined that the drug Vioxx had an increased risk of cardiovascular events before that information was published based on its own internal data.[27] Similarly, within 90 minutes of learning of the withdrawal of Vioxx from the market, the Cleveland Clinic queried its EHR to see which patients were on the drug. Within 7 hours they deactivated prescriptions and notified clinicians via e-mail.[28] This will be discussed in more detail in the patient safety chapter.

Quality reports are far easier to generate with an EHR compared to a paper chart that requires a chart review. Quality reports can also be generated from a data warehouse that receives data from an EHR and other sources.[29] Quality reports are the backbone for pay for performance which we will discuss further in another chapter.

- **Public expectations**. According to a 2006 Harris Interactive Poll for the Wall Street Journal Online, 55% of adults thought an EHR would decrease medical errors; 60% thought an EHR would reduce healthcare costs and 54% thought that the use of an EHR would influence their decision about selecting a personal physician.[30] The Center for Health Information Technology would argue that EHR adoption results in better customer satisfaction through fewer lost charts, faster refills and improved delivery of patient educational material.[31]

- **Governmental expectations**. Right or wrong, EHRs are considered to be the "silver bullet" by many in the federal government. More legislation is being introduced to promote electronic health records as outlined earlier in this chapter. It is the goal of the US Government to have an interoperable electronic health record within the next decade. In addition to federal government support, states and payers have initiatives to encourage EHR adoption. Many organizations state that we need to move from the "cow path" to the "*information highway*". Medicare is acutely aware of the potential benefits of EHRs to help coordinate disease management in older patients.

- **Financial savings**. The Center for Information Technology Leadership (CITL) has suggested that ambulatory EHRs would save $44 billion yearly and eliminate more than $10 in rejected claims per patient per outpatient visit. This organization concludes that not only would there be savings from eliminated chart rooms and record clerks; there would be a reduction in the need for transcription. There would also be fewer callbacks from pharmacists with electronic prescribing. It is likely that copying expenses and labor costs would be reduced with EHRs. More rapid retrieval of lab and x-ray reports results in time saving as does the use of templates. More efficient patient encounters mean more patients

could be seen each day. Improved savings from medication management is possible with reminders to use the "*drug of choice*" and generics.[32]

It is not known if EHR adoption will decrease malpractice, hence saving physician and hospital costs. A 2007 Survey by the Medical Records Institute of 115 practices involving 27 specialties showed that 20% of malpractice carriers offered a discount for having an EHR in place. Of those physicians who had a malpractice case in which documentation was based on an EHR, 55% said the EHR was helpful.[33]

- **Technological Advances**. The timing seems to be right for electronic records partly because the technology has evolved. The Internet and World Wide Web make the application service provider (ASP) concept for an electronic health record possible. An ASP option means that the EHR software and patient data reside on a remote web server that you access via the Internet from the office, hospital or home. Computer speed, memory and bandwidth have advanced such that digital imaging is also a reality, so images can be part of an EHR system. Standard PCs, laptops and tablet PCs continue to add features and improve speed and memory while purchase costs drop. Wireless and mobile technologies permit access to the hospital information system, the electronic health record and the Internet using a personal digital assistant, smart phone or laptop computer. The chapter on interoperability will point out that health information organizations can link EHRs together and a Nationwide Health Information Network (NHIN) can link the regions together.
- **Older and more complicated patients require more coordinated care**. According to a Gallup poll it is extremely common for older patients to have more than one physician as evidenced by the following statistics:
    - No physicians—3%
    - 1 physician—16%
    - 2 physicians—26%
    - 3 physicians—23%
    - 4 physicians—15%
    - 5 physicians—6%
    - 6+ physicians—11% [34]

Having more than one physician mandates good communication between the primary care physician, the specialist and the patient. This becomes even more of an issue when different healthcare systems are involved. A 2000 *Harris Interactive* survey reported that physicians understand that adverse outcomes result from poor care coordination with chronically ill patients.[35] Nevertheless, a survey of patients with chronic conditions showed that 18% of the population received duplicate tests/procedures, 17% received conflicting information from other clinicians and 14% received different diagnoses from different physicians.[36] In the future, electronic health records will be integrated with health information organizations so that inpatient and outpatient patient-related information can be accessed and shared, thus improving communication between disparate healthcare entities. Home monitoring (telehomecare) can transmit patient data from home to an office's EHR also assisting in the coordination of care.

Electronic Health Record Key Components

The following components are desirable in any EHR system. The reality is that many EHRs do not currently have all of these functions.

- Clinical Decision Support Systems (CDSS) to include alerts, reminders and clinical practice guidelines. CDSS is associated with computerized physician order entry (CPOE). This will be discussed in more detail in this chapter and the patient safety chapter
- Secure messaging (e-mail) for communication between patients and office staff and among office staff. Telephone triage capability is important
- An interface with practice management software, scheduling software and patient portal (if present). This feature will handle billing and benefits determination. We will discuss this further in the chapter on practice management systems
- Managed care module for physician and site profiling. This includes the ability to track Health plan Employer Data and Information Set (HEDIS) or similar measurements and basic cost analyses
- Referral management feature
- Retrieval of lab and x-ray reports electronically
- Retrieval of prior encounters and medication history
- Computerized Physician Order Entry (CPOE). Primarily used for inpatient order entry but ambulatory CPOE also important. This will be discussed in more detail later in this chapter
- Electronic patient encounter. One of the most attractive features is the ability to create and store a patient encounter electronically. In seconds you can view the last encounter and determine what treatment was rendered
- Multiple ways to input information into the encounter should be available: free text (typing), dictation, voice recognition and templates
- The ability to input or access information via a PDA, smart phone or tablet PC
- Remote access from the office or home
- Electronic prescribing
- Integration with a Picture Archiving and Communication System (PACS), discussed in a separate chapter
- Knowledge resources for physician and patient, embedded or linked
- Public health reporting and tracking
- Ability to generate quality reports for reimbursement, discussed in the chapter on pay-for-performance
- Problem summary list that is customizable and includes the major aspects of care: diagnoses, allergies, surgeries and medications. Also, the ability to label the problems as acute or chronic, active or inactive
- Ability to scan-in text or use optical character recognition (OCR)
- Ability to perform evaluation and management (E & M) determination for billing
- Ability to create graphs or flow sheets of lab results or vital signs
- Ability to create electronic patient lists or disease registries
- Preventive medicine tracking that links to clinical practice guidelines

- Security compliant with HIPAA standards
- Backup systems in place
- Ability to generate a continuity of care document (CCD) or continuity of care report (CCR), discussed in the interoperability chapter
- Support for client server or application service provider (ASP) option [37]

Computerized Physician Order Entry (CPOE)

CPOE is an EHR feature that processes orders for medications, lab tests, x-rays, consults and other diagnostic tests. A great majority of articles about CPOE have discussed medication ordering only, giving readers the impression that CPOE is the same as electronic prescribing. The reality is that CPOE has a great deal more functionality as we will later point out. Many organizations such as the Institute of Medicine and Leapfrog see CPOE as a powerful instrument of change. There is evidence that CPOE will:

1. **Reduce medication errors**. CPOE has the potential to reduce medication errors through a variety of mechanisms.[38] Because the process is electronic, you can embed rules-engines that allow for checking allergies, contraindications and other alerts. Koppel et al[39] lists the following advantages of CPOE compared to paper-based systems:
    a) CPOE overcomes the issue of illegibility
    b) Fewer errors are associated with ordering drugs with similar names
    c) More easily integrated with decision support systems than paper
    d) CPOE is easily linked to drug-drug interaction warnings
    e) More likely to identify the prescribing physician
    f) Able to link to adverse drug event (ADE) reporting systems
    g) Able to avoid medication errors like trailing zeros
    h) CPOE will create data that is available for analysis
    i) CPOE can point out treatment and drugs of choice
    j) Has the potential to reduce under and over-prescribing
    k) Prescriptions reach the pharmacy quicker
2. **Reduce costs**. Several studies have shown reduced length of stay and overall costs in addition to decreased medication costs with the use of CPOE.[40] Tierney was able to show in 1993 an average savings of $887 per admission when orders were written using guidelines and reminders, compared to paper based ordering that was not associated with clinical decision support.[41]
3. **Reduce variation of care**. One study showed excellent compliance by the medical staff when the drug of choice was changed using decision support reminders.[42] Study conclusions should be interpreted with some note of caution. Many of the studies were conducted at medical centers with well established medical informatics programs where the acceptance level of new technology is unusually high. Several of these institutions such as Brigham and Women's Hospital developed their own EHR and CPOE software. Compare this experience with that of a rural hospital that is trying CPOE for the first time with potentially inadequate IT, financial and leadership support. It is likely that smaller and more rural hospitals and offices will have a steep learning curve.

On the surface CPOE seems easy: just replace paper orders with an electronic format. The reality is that CPOE represents a significant change in work flow and not just new technology. An

often repeated phrase is "*it's not about the software, dummy*", meaning, regardless which software program you purchase, it requires a change in the way you do business or work flow.

Adoption of CPOE has been slow, partly because of cost and partly because work flow is slower than scribbling on paper.[43] Although physicians have been upset by new changes that do not shorten their work day, many authorities feel EHRs greatly improve numerous hospital functions. There has been less resistance traditionally in teaching hospitals with a track record of good informatics support. Also, young house staff who work in teaching hospitals and who write the majority of orders are more likely to be tech savvy and amenable to change. It does require great forethought, leadership, planning, training and the use of physician champions in order for CPOE to work. According to some, CPOE should be the last module of an EHR to be turned on and alerts should also be phased in to bring about change more gradually. Others have recognized nurses as more accepting of change and willing to teach docs "*one-on-one*" on the wards.

For more information on CPOE we refer you to a monograph "*A Primer on Physician Order Entry*" and an article "*CPOE: benefits, costs and issues*".[44-45] Note that CPOE and CDSS will also be further discussed in the chapter on patient safety.

Clinical Decision Support Systems (CDSS)

Traditionally, CDSS meant computerized drug alerts and reminders as part of computerized physician order entry (CPOE) applications. Most of the studies in the literature evaluated those two functions. However, according to Hunt, CDSS is "*any software designed to directly aid in clinical decision making in which characteristics of individual patients are matched to a computerized knowledge base for the purpose of generating patient specific assessments or recommendations that are then presented to clinicians for consideration*"[46] Therefore, CDSS should have a broader definition than just alerts and reminders.

Two papers published in 2005 addressed the effects of CDSS on clinical care. Garg et al performed a systematic review of the literature looking at how CDSS would affect practitioner performance and patient outcomes. He concluded that overall, CDSSs improved performance in 64% of the 97 studies analyzed. This included CDSSs involved with diagnostic, reminder, disease management and drug-dosing support. They were able to show, however, that only 13% of the 52 studies analyzed reported improvement in patient outcomes.[47] The other paper looked at those factors that contributed to the success of CDSS: automatic CDSS that was part of clinician work flow; recommendations and not just assessments; provision of CDSS at the point of care and computer based CDSS (not paper based). When these four features were present, CDSSs improved clinical care about 94% of the time.[48]

Sheridan and Thompson have discussed various levels of CDSSs: (level 1) all decisions by humans (level 2) computer offers many alternatives (level 3) computer restricts alternatives (level 4) computer offers only one alternative (level 5) computer executes the alternative if the human approves (level 6) human has a time line before computer executes (level 7) computer executes automatically, then notifies human (level 8) computer informs human only if requested (level 9) computer informs human but is up to computer (level 10) computer makes all decisions.[49] Most EHR systems may offer alternatives and provide reminders but make no decisions on their own.

Table 2.5 outlines some of the clinical decision support available today. Calculators, knowledge bases and differential diagnoses programs are primarily standalone programs but they are slowly being integrated into EHR systems.

1. **Knowledge support**. Numerous digital medical resources are being integrated with EHRs. As an example, the American College of Physician's PIER resource is integrated into Allscript's Touch Chart.[50] UpToDate is now available in General Electric's Centricity EHR and

eClinicalWorks.[51] IConsult (offered by Elsevier) is a primary care information database available for integration into EHRs. Diagnostic (ICD-9) codes can be hyperlinked to further information or you can use *infobuttons*. Other products such as Dynamed, discussed in the chapter on online medical resources are available as *infobuttons*. Figure 2.3 shows an example of iConsult integrated with the Epic EHR.[52]

Table 2.5 Clinical decision support

Type of CDSS	Examples
Knowledge	iConsult®, Theradoc®
Trending/ Patient tracking	Flow sheets graphs
Medications	CPOE and drug alerts
Order sets/protocols	CPGS and order sets
Reminders	Mammogram due
Differential diagnosis	Dxplain®
Radiology CDSS	What imaging studies to order?
Laboratory CDSS	What lab tests to order

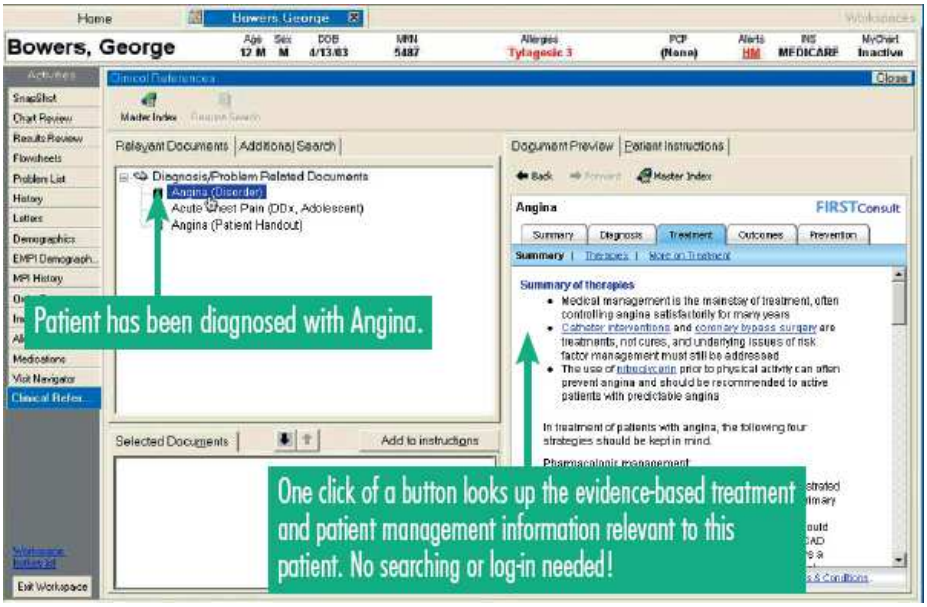

Bowers, George
Patient has been diagnosed with Angina.
One click of a button looks up the evidence-based treatment and patient management information relevant to this patient. No searching or log-in needed!

Figure 2.3 iConsult integrated with Epic EHR (courtesy iConsult)

Another interesting integrated knowledge program is the Theradoc Antibiotic Assistant. The program integrates with an inpatient EHR's lab, pharmacy and radiology sections to make suggestions as to the antibiotic of choice with multiple alerts. Clinicians can be alerted via cell phones, pagers or e-mail. Other modules include Adverse Drug Event (ADE) Assistant, Infection Control Assistant and Clinical Alerts Assistant.[53] A study in the New England Journal of Medicine (NEJM) using this product showed considerable improvement in the prescription of appropriate antibiotics resulting in cost saving, reduced length of stay and fewer adverse drug events.[54]

1. **Calculators**. It is likely with time that more calculators will be embedded into the EHR, particularly in the medication and lab ordering sections. Below is the standalone web and Pocket PC based program Medcalc3000 with over 100 calculations available. They now offer a "Connect" option that will integrate with EHRs by linking calculators, clinical criteria tools and decision trees.[55]

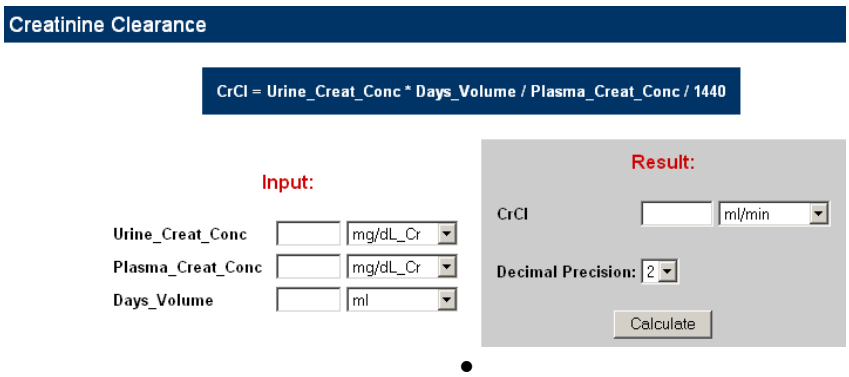


Figure 2.4 Medcalc3000 (courtesy Medcalc3000)

2. **Flow sheets, graphs, patient lists and registries**. The ability to track and trend lab results and vital signs, for example, in diabetic patients will greatly assist in their care. Furthermore, the ability to use a patient list to contact every patient taking a recalled drug will improve patient safety. Registries will be covered in more detail in the disease management chapter.
3. **Medication ordering support**. Many aspects of medication safety to include alerts will be covered in the patient safety chapter. Decision support as part of CPOE possesses several rules engines to detect known allergies, drug-drug interactions and excessive dosages. As EHRs and CPOE mature, they will factor in the age, gender, weight, kidney (renal) and liver (hepatic) function of the patient, known contraindications based on known diagnoses as well as the pregnancy and lactation status. Incorporation of these more robust features is complicated and best implemented at medical centers with an established track record of development of CDSS and CPOE. As has been pointed out, there are programs that improve antibiotic ordering based on data residing in the EHR.[56]
4. **Reminders**. Computerized reminders that are part of the EHR assist in tracking the yearly preventive health screening measures, such as mammograms. Shea performed a meta-analysis of 16 random controlled trials that looked at the role of computerized reminders and preventive care and concluded that there was clear benefit for vaccinations, breast cancer and colorectal screening, but not cervical cancer screening.[57] A well designed system should allow for some customization of the reminders as national recommendations change. Reminders are not always heeded by busy clinicians who may choose to ignore them. As a possible solution, preventive reminders could be reviewed by the office nurse and overdue

tests ordered prior to the visit with the physician. More information on CDSS and reminders can be found in the chapter on patient safety.

5. **Order sets and protocols**. Order sets are groups of pre-established orders that are related to a symptom or diagnoses. For instance, you can create an order set for pneumonia that might include antibiotics, oxygen, repeat chest x-ray, etc that saves keystrokes and time. Order sets can also reflect best practices (clinical practice guidelines), thus offering better and less expensive care. Over one hundred clinical practice guidelines are incorporated into the electronic health record at Vanderbilt Medical Center.[58] An excellent 2007 review of order sets as part of CDSS was reported in the Journal of the American Medical Informatics Association.[59]
6. **Differential Diagnoses**. Dxplain is a differential diagnosis program developed at Massachusetts General Hospital. When you input the patient's symptoms it generates a differential diagnosis (the diagnostic possibilities). The program has been in development since 1984 and is currently web based. A licensing fee is required to use this program. At this time it cannot be integrated into an EHR.[60] In spite of the potential benefit, an extensive 2005 review of CDSSs revealed that only 40% of the 10 diagnostic systems studied showed benefit, in terms of improved clinician performance.[61]
7. **Radiology CDS**. Physicians, particularly those in training, may order imaging studies that are either incorrect or unnecessary. For that reason, several institutions have implemented clinical decision support to try to improve ordering. Appropriateness criteria have been established by the American College of Radiologists. Massachusetts General Hospital has had radiology order entry since 2001 and studied the addition of decision support. They noted a decline in low utility exams from 6% down to 2% as a result of decision support.[62]
8. **Laboratory CDS**. It should be no surprise that clinicians occasionally order inappropriate lab tests, for a variety of reasons. It would be helpful if clinical decisions support would alert them to the indications for a test, as well as the price. A Dutch study of primary care demonstrated that 20% fewer lab tests were ordered when clinicians were alerted to clinical guidelines.[63]

How well clinicians use CDSS programs such as those discussed, remains to be seen. They will have to be intelligently designed and rigorously tested in order to be accepted. Bates, et al offers the Ten Commandments for effective clinical decision support:

- Speed is everything—provide the information rapidly
- Anticipate needs and deliver in real time—make it convenient and provide at the point of care
- Fit into the users workflow—provide information in a screen that is logical and not in a separate standalone application
- Little things make a big difference—subtle details may make or break CDSS
- Recognize that physicians will strongly resist stopping—because of this some monitoring of clinicians who ignore important guidelines may be necessary
- Changing direction is easier than stopping—a helpful reminder to make a minor change (like lower dose of med) is better accepted than a complete change
- Simple interventions work best—guidelines should fit on a single screen

- Ask for additional information only when you really need it—clinicians will object to having to find information that is not readily available
- Monitor impact, get feedback and respond—suffice it to say that no system will work without getting feedback from the end user and tweaking it as needed
- Manage and maintain your knowledge based systems—there is a need to update recommendations as new evidence appears[64]

For more information on CDSS, we refer you to these excellent resources.[65-68]

Electronic Health Record Examples

We will start by mentioning some less expensive choices, available in 2009 that offer a moderate amount of functionality.

Open-Source and Free EHRs.

Wikipedia lists more than 10 national and international open-source EHRs.[69] While most open-source EHRs are inexpensive, free means freedom to copy or distribute and not without cost.[70] There are usually charges to install and support the system and additional charges to obtain ICD-9 and CPT codes. CCHIT is actively discussing the issue of certification for open-source EHRs in 2009, as the certification fee is cost-prohibitive for most open-source initiatives. Of note is the fact that the stimulus package mentions that the Secretary of HHS should evaluate the impact of open-source healthcare applications by 2010. Open-source in healthcare is discussed in more detail in the last chapter on emerging trends.

- **OpenVista** is an open-source initiative based on the popular VistA program the VA system uses and is available for download without charge.[71]
- **WorldVistA** is basically the same EHR the Veteran's Affairs (VA) system uses without the inpatient function. It was released in October 2005 as a joint venture between the VA and the Centers for Medicare and Medicaid Services to promote a more affordable EHR for the US and third world countries (VistA-Office Project). It is written with old MUMPS programming. Version VOE/1 was approved by CCHIT in 2006. Features include:
    - Patient registration
    - Lab and vital signs graphing
    - Clinical reminders for chronic disease management
    - Clinical order entry
    - Progress note templates
    - Results reporting
    - Ability to interface to existing practice management/billing systems, lab services and other applications
    - Scanning and inclusion of scanned documents into the medical record
    - Prescription filing and faxing
    - Clinical quality measure reporting capabilities
    - Support for disease management, using clinical reminders

  - Templates for obstetrics/gynecology (OB/GYN) and pediatrics care[72]

- **Medsphere OpenVista** is a vendor that will offer an open source version on a subscription basis that covers upgrades and support. Their program is offered in two configurations: enterprise for an organization and clinic configuration for smaller clinics and multi-specialty groups. The software will operate on a Linux or Windows operating system.[73]
- **OpenEMR** is a open-source GPL license EHR with practice management, electronic billing, the ability to generate electronic prescriptions and HL7 support. It is intended for small ambulatory practices and available as a client-server or ASP model.[74]
- **PracticeFusion** is mentioned because it is a free, easy to use ASP model EHR funded by small advertisements on each screen and the sale of de-identified data. They claim 18,000 users as of mid-2009.The program includes scheduling, patient encounters, knowledge resources, growth charts, advanced directives, customizable templates, the ability to upload documents and a fee-based billing interface and fee-based document copying service.[75]
- **MDBug** is another free web-based EHR that has a billing service, lab interfaces and a patient portal that includes secure messaging, access to lab results, online appointments, online bill payment and access to online forms. Both of these EHRs anticipate compliance with Medicare/Medicaid reimbursement within the next year.[76]

Low Cost EHR Programs

Medical Office Online. This web-based (ASP) EHR is priced at $300/physician per month, plus a user license of $15 per user per month and an initial set up and training fee of $695 to import data. They are not CCHIT certified as of mid-2009. The main features offered include:

- Patient demographics
- The ability to scan and attach insurance cards, photo IDs, images and attachments
- Scheduling
- Automatic CPT and ICD-9 charge capture
- Evaluation and Management (E & M) coding
- Prescription generation
- Letter templates
- Refill requests
- Patient education handouts
- Discount for charity-type clinics
- Practice Management: Charge capture, accounts receivable, electronic claims submission and billing[77]

SoapWare. This program is very popular among small primary care practices but also covers more than 60 specialties and exists in more than 30+ countries. Patient encounter data can be inputted by templates or voice recognition. They are CCHIT certified and qualified for Medicare/Medicaid reimbursement. Training and implementation are extra. As of mid-2009 they offer three packages:

- SOAPwareRX: $995 for basic EHR with e-prescribing. No charge for staff access

- SOAPware Standard: $1995 for CCHIT certified EHR
- SOAPware Professional: $3995 with functionality like standard model plus data mining and reports, E&M coding, alerts and interfaces
- Training and implementation are extra
- Support package is an annual cost and depends on which package you purchase. First year is included in purchase price
- ASP professional model starts at $250 per month
- Optional: HL7 interface, billing, knowledge resources, fax capability, back up services[78]

Other similar EHR programs:

- Amazing Charts www.AmazingCharts.com
- InteGreat www.igreat.com (2006 CCHIT certified)
- Praxis EMR www.praxisemr.com(2006 CCHIT certified)
- E-MDS www.e-mds.com (2008 CCHIT certified and eligible for Medicare/Medicaid reimbursement)
- SpringCharts www.springcharts.com (2006 CCHIT certified)
- ComChart www.comchart.com

More Comprehensive EHR Examples

Armed Forces Health Longitudinal Technology Application (AHLTA). This is the program (previously known as CHCS II) that has been deployed worldwide for every Department of Defense (DOD) medical facility (9.2 million patients). It began as CHCS I in about 1992 and was used primarily for outpatient order entry and the ability to retrieve lab, x-ray and pharmacy results. AHLTA is more robust than CHCS I with the ability to use templates to input information into a patient encounter. A unique feature of this EHR is the use of the MEDCIN terminology engine. MEDCIN is a collection of 200,000+ terms you can select to construct a history and physical exam. This was selected in order to create a structured note, so each data field can be saved and retrieved and the information can build an Evaluation and Management (E & M) code. The limitation is that it is very time consuming to learn to use this technique and then create your own list of customized profiles. Specialists are used to dictating a very comprehensive note, whereas the use of templates tends to generate very short cryptic notes. Needless to say, templates and MEDCIN have their advocates and their skeptics. In figure 2.5 is an example of MEDCIN terminology where you can search for the correct terms to input into the patient note. AHLTA has an extensive CPOE application for ambulatory care only. Note the features listed in the left pane below. Other limitations are the lack of interoperability with the VA system, lack of an inpatient module and the inability to input/scan documents into the EHR. Excellent demos can be found on a training web site, customized for "providers", nurses, support techs and clerks.[79-80]

Veterans Health Administration VistA. In 1996, the VA introduced VISTA (Veterans Health Information Systems and Technology Architecture). Computerized Patient Record System (CPRS) is the graphic user interface (GUI) for the Veteran's EHR system that serves approximately 7.5 million enrollees (Figure 2.6). CPOE accounts for 93% of all prescriptions and the VA system processes approximately 860,000 orders daily. Image archiving and bar coded medication

administration is part of VistA. This EHR is currently used in outpatient, inpatient, Mental Health, intensive care unit (ICU), Emergency Department, Clinic, Homecare, Nursing Home and other

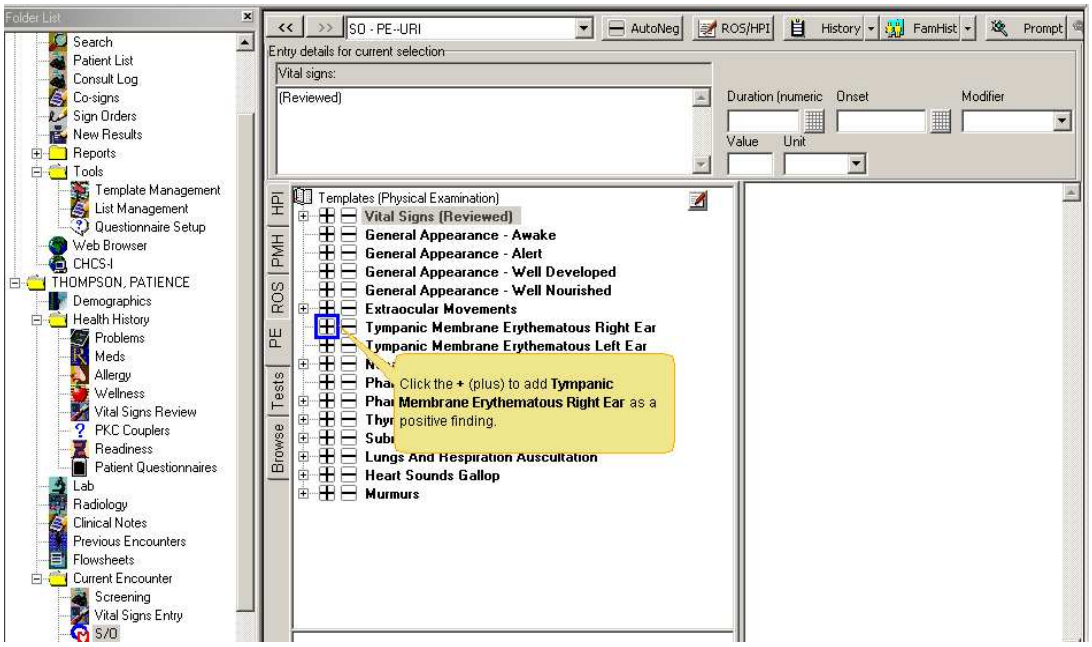


Figure 2.5 AHLTA and MEDCIN terminology engine
(adapted from the Naval Medical Center Portsmouth web site)

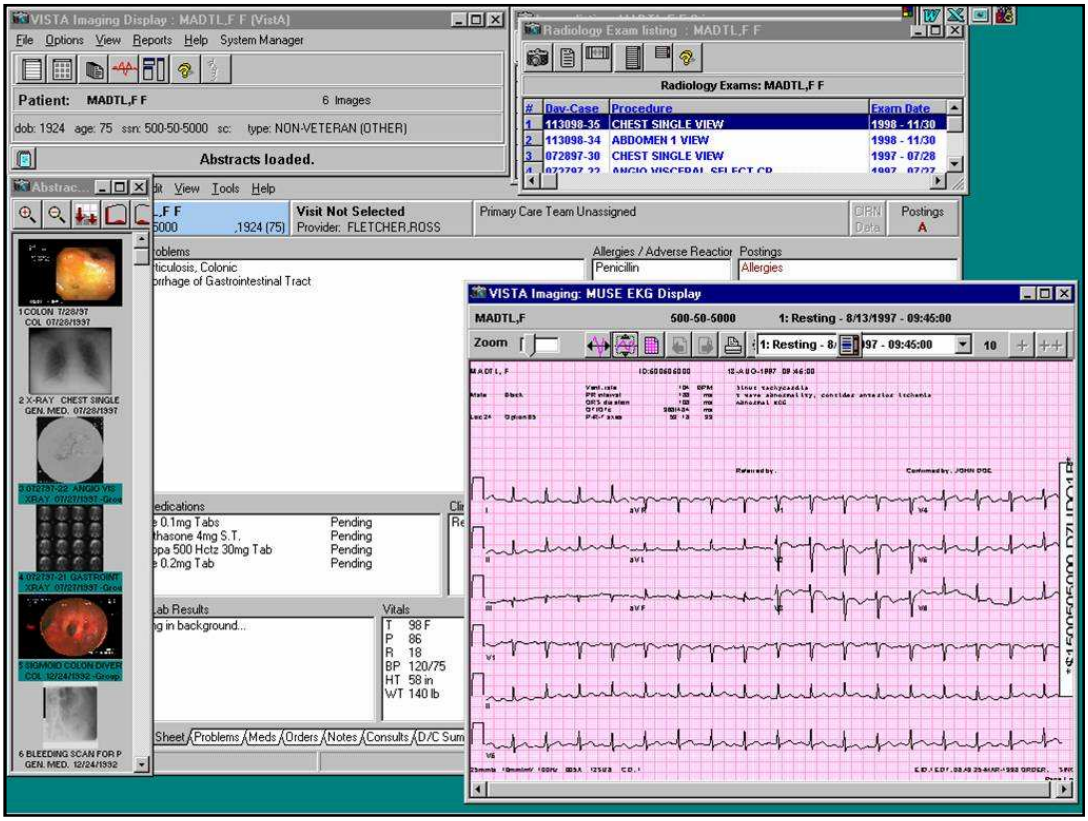


Figure 2.6 VISTA CPRS (courtesy Veteran's Affairs)

settings. Unfortunately, it was built on an old MUMPS programming like CHCS I but will eventually migrate to a more modern architecture and will be known as HealtheVet. The newer architecture will likely be an ASP model and will allow for improved interoperability with other VA facilities and information exchanges. In spite of the older programming language this EHR has been well received by clinicians and considered one of the major transformational factors in VA healthcare. The program has a new patient portal, My HealtheVet, that allows patients to enter lab and vital signs and create a personal health record.[81-84]

Kaiser Permanente HealthConnect. The largest roll-out of a civilian EHR in the world (8.6 million members) was begun by Kaiser-Permanente in 2003 and completed by 2008. This four billion dollar project uses the Epic Systems EHR and has experienced its share of obstacles with implementation. The goal of this non-ASP model EHR is to integrate all electronic aspects of patient care into one system: billing, inpatient and outpatient records, registration, scheduling, lab, x-ray and pharmacy records. They offer a personal health record known as My Health Manager with the following features:

- Online appointments
- Online refills
- Access to lab results
- Eligibility and benefits
- Access to immunization records
- Secure messaging to physicians[85-86]

eClinicalWorks. As mentioned, there are over 300 commercial vendors promoting their EHRs but fewer than 20 that have a significant market share. We will discuss this EHR to give readers a better idea of the features offered by many commercial EHR vendors. This EHR was selected by the Massachusetts Medical Society because it is multi-featured and directed at small, medium and large practices. It is also one of the few that lists its pricing schedule on their web site.

Available features include:

- "Do Lists" are always posted at the top of the screen and are colored coded as to urgency
- Multiple means of inputting data such as templates, handwriting recognition, voice recognition and free text
- Sticky note feature for reminders
- Separate window to let physician know if patient owes the practice money
- Tab to access the resource UpToDate
- Patient can pre-register ahead of time on the patient portal eClinicalWeb
- True e-prescribing transmission of scripts to a pharmacy and not just a printed script or fax
- Continuity of Care Record (electronic patient summary) available
- The ability to create customizable digital practice forms
- Patient education resource
- Comprehensive patient/disease registries with customizable alerts
- Referral letters can be automatically generated
- A summary of the visit can be printed and given to the patient

- E-visit capability
- eClinicalMobile will host the EHR on an iPhone in 2009

- Mid-2009 pricing:
    - Client-server purchase price of $10,000 for first clinician, then $5,000 for additional clinicians. Maintenance fee is 0.18% of total price and support fees of $600 per month
    - Client server lease at $4800 for first clinician, $4320 for second clinician
    - Remote hosting (ASP) at charge of $400 per month per clinician and hosting fee of $300 per month
    - EHR ASP model will be offered along with Dell Computers as a packaged deal by Sam's Club in 2009[87]

Specialty EHRs. The EHR vendor NexGen EHR offers 24 sub-specialty patient encounter modules. A customized EHR for sub-specialties makes sense because their needs are narrower and different than those of a primary care physician. An excellent example is their ophthalmology module that organizes the EHR into a very logical order for eye physicians. Their product is available as a client-server or ASP option. The history and physical exam can be specialty specific and images can be stored in each patient's record. Coding is automatically generated, as are letters back to the referring physician. A PDA version is also available. They also offer practice management, document scanning, a patient portal and a community health module (central data repository).[88-89]

EHR Successes and Failures

Duke University Medical Center

- EHR developed in 1986
- Total time per patient visit was reduced by 13%
- Pre-exam functions were reduced
- Fewer overlooked problems
- Fewer charting errors
- Fewer prescription errors
- Physician's actual time with patient unchanged[90]

Central Utah Multi-specialty Clinic

- 59 physicians practicing in nine locations
- Clinic used Allscripts Touchworks EHR
- In first year they experienced $900,000 profit due to increased revenue and decreased expenses
- They anticipate savings of $8.3 million over next 5 years[91]

University of Rochester

- Implemented Allscripts Touchworks EHR for three Internal Medicine Clinics, one Dermatology clinic and a Pediatric Endocrinology clinic
- ROI occurred in 16 months with ongoing annual savings of almost $10,000 per physician
- Reduction in chart pulls accounted for 63% of savings
- Salary savings accounted for 23% of savings[92]

Maimonides Medical Center

- With a new EHR system medication discrepancies fell by 60%
- 165,000 potential drug interactions were detected (unknown how many were truly serious) in one year resulting in 82,000 treatment changes
- System used by 100% of medical staff[93]

Cincinnati Children's Hospital Medical Center

- Partial EHR based on Siemens software implemented at a cost of $14 million dollars
- Medication ordering/dispensing errors reduced from 120 to 90 per month
- Program reduced time to get drugs from pharmacy to bedside in half[94]

Cedar-Sinai Hospital

- $34 million CPOE system rolled out in 2003
- Shut down 3 months after implementation because:
- System too slow and too many technical problems
    - Poor physician input
    - No phase-in. Mandated CPOE from the beginning[95]

Barriers to Electronic Health Record Adoption

According to Shortliffe[96], there are four historic constraints to EHR adoption: 1) the need for standardized clinical terminology; 2) privacy, confidentiality and security concerns; 3) challenges to data entry by physicians and 4) difficulties with integrating with other systems. In addition, other barriers exist to include:

1. **Financial Barriers**. Although there are models that suggest significant savings after the implementation of ambulatory EHRs, the reality is that it is expensive. Surveys by the Medical Records Institute, MGMA and HIMSS report that lack of funding is the number one barrier to EHR adoption, cited by about 50% of respondents.[97] In a 2005 study published in *Health Affairs*, initial EHR costs averaged $44 K (range $14-$63,000) per FTE (full time equivalent) and ongoing costs of $8.5 K per FTE. These costs included the purchase of new hardware, etc. Financial benefits averaged about $33,000 per FTE provider per year. Importantly, more than half of the benefit derived was from improved coding. This study looked at fourteen primary care practices using two well known EHRs. The average practice showed a return on investment in only 2.5 years.[98] This is not a surprise given the fact that studies have shown that physicians often "*under code*" for fear of punishment or lack of understanding what it takes to code to a certain level.[99] It is important to consider

that integration with other disparate systems such as practice management systems can be very expensive and hard to factor into a cost-benefit analysis. The web based application server provider (ASP) option is less expensive in the short term and perhaps in the long term, when you factor in the expenses to maintain and upgrade an office client-server network. According to many studies, including a survey by the Commonwealth Fund, adoption of EHR and CPOE was far higher in large physician practices that could afford the initial high cost.[100]

2. **Physician resistance**. In a monograph by Dr. David Brailer, lack of support by medical staff is consistently the second most commonly perceived obstacle to adoption, behind lack of resources.[101] They have to be shown a new technology makes money, saves time or is good for their patients. None of these can be proven for certain for every practice. Although you should not expect to implement CPOE or go paperless from the beginning, at some point it can no longer be optional. It seems clear that CPOE does take longer than written orders but offers multiple advantages over paper as pointed out previously. One systematic review suggests that documentation time for CPOE was far greater for physicians than nurses.[102] Initially productivity will slow down in the office for 3-12 months which is difficult for clinicians, even though their productivity will likely improve above baseline in the future. Too many studies looking at this topic are based on surveys or theoretical models and not high quality research. Implementation will not fix old work flow issues and will not work if several physicians in a group are opposed to going electronic. We now know that some practices have opted to change or discontinue their use of an EHR. A 2007 survey by the Medical Records Institute demonstrated that fewer than 20% of respondents had uninstalled their EHR in an effort to step down to a less expensive alternative and 8% had returned to paper.[103]
3. **Loss of productivity**. It is likely physicians will have to work at reduced capacity for several months with gradual improvement depending on training, aptitude, etc. This is a period when physician champions can help maintain momentum with a positive attitude.
4. **Work flow changes**. Everyone in the office will have to change the way they route information compared to the old paper system. If planning was well done in advance you should know how your work flow will change. Initially, you will have to maintain a dual system of paper and electronic records. Work flow analysis will also determine where you will place computer terminals. Importantly, clinicians will have to maintain eye contact as often as possible and learn to incorporate the EHR into the average patient visit. Use of a movable monitor or tablet PC may help diminish the time the clinician spends not looking at the patient.
5. **Integration with other systems**. Hopefully, integration with other systems like the practice management software was already solved prior to implementation. Be prepared to pay significantly for programmers to integrate a new EHR with an old legacy system. An average cost is about $3-$15,000.[104] Most office and hospitals have multiple old legacy systems that do not talk to each other. Systems are often purchased from different vendors and written in different programming languages. It is now popular to purchase an EHR already integrated with practice management, billing and scheduling software programs. It is worth noting that the open-source Mirth Connect application is a HL7 integration engine that should decrease the cost to integrate disparate systems.[105]
6. **Lack of standards**. One can assume that an EHR purchased today will not communicate with other EHRs, although vendors are being pressured to make their products

interoperable. The Department of Health and Human Services established the Certification Commission for Healthcare Information Technology (CCHIT) with the goal of certifying technologies such as EHRs. Twenty nine ambulatory EHRs have been certified using the 2008 standards. Certification will last for only two years and is expensive, about $35,000 for initial certification. Interoperability testing requires a vendor to receive lab results using the HL7 v.2.5.1 standard, test lab codes using LOINC and generate a continuity of care document.[106] These standards are discussed further in the chapter on interoperability. Of note, the software to test interoperability is available as free open-source to CCHIT and vendors at www.projectlaika.org. EHRs must be certified one year prior to hospitals being allowed to give EHR software to physicians.[107] More information about CCHIT is covered in several other chapters.

7. **Adverse legislation**. There is concern that previously passed legislation will make it difficult for hospitals and physicians to combine forces and create information networks. The Stark Law prohibited a physician from referring Medicare patients to an entity if he/she had a financial relationship with the entity. The Anti-kickback Act made it illegal for an individual or entity to offer remuneration of any kind to another individual or entity for referring a patient. It is illegal to have to purchase or lease any covered item or service. In 2006 "*safe harbor*" exceptions became law and allowed hospitals to provide electronic health records to physicians. However, the physician or office must pay 15% of the donor's cost for the technology.[108]

   Software, but not hardware can be donated and training costs can be donated. Donations must be complete by December 31 2013. It is unclear if these exceptions will result in increased use of EHRs.

8. **Inadequate proof of benefit**. Although there is plenty of hype regarding the benefits of EHRs, the reality is we need better research. A systematic review by Hunt showed that the effects of clinical decision support systems, as an example, have not been adequately studied.46 Moreover, successful CDSS programs at a medical center where they have been in use for an extended period of time does not mean they will be successful at another medical center with no such track record. There have been several studies in 2005 that have shown increased errors as a result of implementing CPOE.[57, 109-111] Most of the studies have been criticized for one reason or another but it should come as no surprise that any new technology will create new possibilities for errors. Weiner coined the term "*e-iatrogenesis*" to mean "*patient harm caused at least in part by the application of health information technology*".[112] Ash et al wrote an excellent 2004 review on the unintended consequences of information technology in health care.[113] Berger and Kichak wrote an insightful but negative appraisal of CPOE entitled "*Computerized Physician Order Entry: Helpful or Harmful*" in which they disputed findings by groups such as the IOM and Leapfrog.[114] Eventually, with better training or re-design some of the technology-related errors are likely to be overcome.

   The Center for Medicare and Medicaid Services (CMS) has outlined a 5 year $150 million pilot program, beginning in 2008, to test the effects of EHR implementation, using 1,200 recruited physicians covering 12 states and cities.[115]

Selecting an Electronic Health Record: The Logical Steps

There is a tendency to pick a well know EHR vendor and hope for the best, much like picking an automobile. Unfortunately the process is far more complex and less dependent on the vendor

selected. More important are the specific needs of the group, careful implementation, adequate training, integration with other systems and buy-in by all staff. The following are steps that should be taken to plan for the purchase and implementation of an EHR.

1. **Develop your office strategy**. List priorities for the practice. Are you trying to save time and/or money or do you just want to go paperless? Are you trying to integrate disparate programs? Now is the time to study work flow and see how it will change your practice. This is when frequent conferences with your front office staff will be critical to get their input about the processes that need to improve. Make sure physicians are committed to using the EHR. Look for at least one physician champion and be sure your staff is onboard. Do not proceed if there are hold-outs. Factor in your future requirements. Do you plan to add more partners or offices or specialties? Plan for initial decreased productivity.
2. **List the EHR features you need**. Review the key components section of this chapter. Choose the method of inputting: keyboard, mouse, stylus, touch screen or voice recognition?
3. **Decide on client-server versus the application service provider (ASP) option**. One early decision that must be made is whether you want to purchase a standard client-server EHR package which means having the software on your own computers. The other choice is an ASP which uses a remote server that hosts the EHR software and your patient data. Each has its merits and shortcomings. Features of an ASP Model:[37]
    a) Vendor charges monthly fees to provide access to patient data on a remote server. Fees will usually include maintenance, software upgrades, data backups and help desk support
    b) Lease agreement commitments range from 1-5 years
    c) ASP may charge a fixed amount or charge for the number of users
    d) ASP can be completely web based or can require a small software program (thin client) to help share processing tasks
    e) Pros: Lower start-up costs; ASP maintains and updates software; requires very little local tech support, thus saves money. Often a better choice for small practices with less IT support. Enables remote log-ons, for example, from home or satellite offices
    f) Cons: If your ISP is not working you aren't either; concerns about security and HIPAA; concerns about who owns the data and cost of monthly cable fees. Speed may be a little slower compared to the client-server model. Must have fast Internet connection; should be cable modem, DSL or T1 line
    g) In 2006 a group of physicians refused to pay for a 400% increase in tech support. As a result, they were denied access to their patient's records [116]
    h) An informal 2009 survey of 324 EHR companies revealed that 54% of the vendors listed an ASP alternative.[117] Another new trend is larger practices or hospitals hosting EHR ASP services for smaller practices to make it affordable.[118] An excellent review of ASPs was published in October 2006 by the California HealthCare Foundation[119]
4. **Do you need a combined EHR and Practice Management System?** Decide early on if you plan to purchase a combined EHR and practice management system or do you need an interface to be created?
5. **Survey hardware and network needs.** How many more computers will you need to buy? Do you need to hardwire a network and/or are you going wireless? Are you going to need an in-house server with its dedicated closet, air conditioning and backup? Do you need a network switch and commercial grade firewall? You will need a data back up and disaster

plan. Plan for a commercial grade uninterruptible power supply. Also, plan for a service level agreement if you opt for the ASP model.

6. **What interfaces do you need?** Will you need interfaces to external laboratory, pharmacy and radiology services or is that part of the package purchased?
7. **Do you need third party software?** As an example: patient education material, ICD-9 codes, CPT codes, HCPCS database, SNOMED, drug database, voice recognition, etc. Ask if that is part of the purchased package.
8. **Develop your vendor strategy.** Write a simple "request for proposal" (RFP) or request for information (RFI). This will cause you to put on paper all of your requirements. Each vendor will need to respond in writing how they plan to address them. Exact pricing should be part of the RFP. Sample RFPs are available on the Web.[120] There is a web based search engine that will search 324 EHR vendors with the filters for practice specialty, practice size, ASP versus client server, EMR or EMR plus PMS and whether the EHR is CCHIT certified.[117] Obtain several references from each vendor and visit each practice if possible. Be sure to select similar practices to yours. The following excellent reference provides an EHR demonstration rating form, questions to ask vendors, EHR references and a vendor rating tool.[121] Create a scoring matrix to compare vendors. Look at several EHR rating sources. Keep in mind that much of the survey data is self-reported by vendors or physicians and not a research organization.[122] Nevertheless, surveys provide valuable information, often difficult to obtain from a web search. There are also several fee-based sites to compare EHR products, such as KLAS.[123-124] The following reference also has a scoring sheet with sections for vendor software, interfaces, third party software, conversion services, implementation services, training services, data recovery services, annual support and maintenance, financing alternatives and terms. It also includes red flags and FAQ's. This reference is intended to compare costs and not EHR functionality between candidate vendors.[125] Obtain in writing commitments for implementation and technical support, including data conversion from paper records; interfacing with practice management (PM) software; exact schedule and time line for training. Who pays for updates? Questions to ask vendors:
    a) How many licenses have been sold overall?
    b) Number of years in business of selling EHRs?
    c) Number of employees and salesmen?
    d) Does the company focus primarily on a certain size practice?
    e) Is there a problem with multiple log-ons at the same time?
    f) Does the EHR interface with other electronic systems?
    g) Does the maintenance fee cover travel and does it cover nights, weekends and holidays?
    h) How much for software upgrades?
    i) Confirm that the EHRs qualifies for Medicare/Medicaid reimbursement
    j) What is the training time required to become truly operational?
    k) Training cost per user or practice?
    l) On-site training available?
    m) Are you willing to put terms in a sales agreement?
    n) Do you plan to stay up to date with CCHIT certification?
    o) Hardware and software requirements?[37]
9. **Look for funding**

a) The most obvious choice is Medicare or Medicaid reimbursement under the HITECH Act
b) A purchase of an EHR in 2009 that includes e-prescribing will permit early reimbursement[126]
c) As noted before, hospitals can donate EHR systems to physician offices under the "safe harbor" with physicians having to pay 15% of costs
d) CMS EHR Demonstration project. 1,200 practices in 13 states are eligible to receive $58,000 per physician or $290,000 for the practice over five years. Because of the newer stimulus package, phase II of this project will not occur[127]
e) Physician Quality Reporting Initiative (PQRI) will reward physicians for quality reports that can be generated by an EHR. We will cover this more in the chapter on pay for performance[128]
f) There are incentive programs by states, payers and hospitals [129-130]

An interesting article written by Trachtenbarg in 2007 reviews the myths and truths about EHR (Table 2.6).[131]

Table 2.6 Myths and Truths about EHRs

Myths	Truths
"*A new EHR will fix everything*"	The reality is that it will only solve a few problems and probably create a few new ones
"*Brand A is the best*"	No single vendor has an ideal product and you must determine which features you need as each practice is unique
"*Our software needs to work the way we currently work*"	Expect to make some changes in your workflow and analyze that ahead of time
"*Software will eliminate errors*"	Expect a reduction, not elimination of medication errors, with a few new errors appearing
"Discrete data is always best"	In spite of the fact that structured (computable) data has advantages, it is clumsy and reads poorly
"*The more templates the better*"	Don't make any more templates than you actually need
"*Mobile is best*"	Having your EHR on a PDA phone or tablet PC sounds cool but a substantial number of clinicians won't use them
"*You must have a detailed plan and stick to it*"	You must remain flexible as needs, equipment and reimbursement change over time
"*You can stop planning*"	Planning never stops because better systems will be available in the future

For a recent real-world study of EHR implementation by a group of four Internists reported in the literature, see reference.[132] According to one author:

"Despite the difficulties and expense of implementing the electronic health record, none of us would go back to paper"

For further reading on electronic health records we refer you to the University of West Florida's resource site at www.uwf.edu/sahls/medicalinformatics

Key Points

- Electronic health records are central to creating a national interoperable system of electronic health records
- The current paper-based system is fraught with multiple shortcomings
- It is likely that reimbursement for e-prescribing and electronic health records by the federal government will promote adoption
- In spite of the potential benefits of electronic health records, obstacles and controversies persist
- Computerized physician order entry and clinical decision support are still in their infancy and will likely improve in the future with artificial intelligence
- Advance planning and training is mandatory for successful implementation of electronic health records

Conclusion

In spite of the slow acceptance of EHRs by clinicians and healthcare organizations, they continue to proliferate and improve over time. Electronic health records have been transformational for large organizations like the VA, Kaiser-Permanente and the Cleveland Clinic but the reality is that most medicine in this country is practiced by small medical groups, with limited finances and IT support. As a new trend, we are seeing outpatient clinicians opt to re-engineer their business model based on an EHR. Their goal is to reduce overhead by having fewer support staff and to concentrate on seeing fewer patients per day but with more time spent per patient. When this is combined with secure messaging, e-visits and e-prescribing the goal of the "*e-office*" is achievable.[133]

Buyers have a wide choice of features and cost to choose from. At this time cost is a major obstacle as well as the lack of high quality economic studies demonstrating reasonable return on investment. As more studies show cost savings, medical groups that have been sitting on the fence will make the financial commitment.

Without doubt, Medicare and Medicaid reimbursement for EHRs and e-prescribing is the most significant impetus to jump start EHR adoption we have seen. We anticipate a flurry of activity in 2009 and 2010 in preparation for reimbursement. Optimistically, we will see a variety of EHRs qualify for reimbursement. Clearly, "one size does not fit all" applies to EHRs. For those practices that can afford and need complexity, multiple high-end vendors exist. For smaller, rural, primary care practices, simpler alternatives exist, to include open-source EHRs. Expect little progress until the final definition of meaningful use is available in early 2010. In October 2009 CCHIT released the 2011 Certification criteria for ambulatory EHRs. Vendors can opt to be "CCHIT Certified® 2011" which means the EHR meets or exceeds federal standards or they can opt for "preliminary certification" that means it will meet federal standards. Details and pricing are included on their web site. [134]

It is also worth noting that purchasing EHRs is only one of multiple difficult challenges facing clinicians and their staff. According to a mid-2009 Medical Group Management Association (MGMA) survey implementing an EHR was ranked third in difficulty followed by rising operating costs and maintaining clinician salaries in the face of decreasing reimbursement. [135]

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3

Integrated Practice Management Systems

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Learning Objectives

After reading this chapter the reader should be able to:

- Document the workflow in a medical office that utilizes a practice management (PM) system integrated with an electronic health record system
- Compare the functionality of a standalone PM system with fully integrated PM software as part of a robust EHR system
- Identify the features of an integrated practice management system
- List the most common integrated PM software packages currently available
- Identify the key advantages and obstacles in converting from paper records and a standalone PM system to an integrated PM with EHR system
- Discuss emerging trends in practice management

"*In an environment where quality is quantitatively and qualitatively measured, an administrator will be judged to be productive if his or her work leads to an organization performing at a higher level in the metrics of cost, quality, and service.*"
Rick Madison and Ken Clarke, Group Practice Journal

Most medical offices have had computerized practice management (PM) systems for many years, regardless of whether that office maintains paper medical records, electronic health records (EHRs) or records that are a hybrid of these two. As we will point out there are many reasons why PM systems have become so prevalent but one of the main reasons is for more rapid claims submission and adjudication. Without an electronic system, time and money would be lost on faxes, phone calls and snail mail. The American Medical Association estimated that inefficient claims submission systems lead to about $210 billion annually in unnecessary costs.[1] A PM system is designed to capture all of the data from a patient encounter necessary to obtain reimbursement for the services provided. This data is then used to:

- Generate claims to seek reimbursement from healthcare payers
- Apply payments and denials
- Generate patient statements for any balance that is the patient's responsibility
- Generate business correspondence
- Build databases for practice and referring physicians, payers, patient demographics and patient encounter transactions (i.e., date, diagnosis codes, procedure codes, amount charged, amount paid, date paid, billing messages, place and type of service codes etc)

Additionally, a PM system provides routine and ad hoc reports so that an administrator can analyze the trends for a given practice and implement performance improvement strategies based on the findings. For example, a medical office administrator is able to use the PM system to compare and contrast different payers with regards to the amount reimbursed for each given service or the

turnaround time between claims submission and payment. The results lead to deciding which managed care plans the practice will participate in versus those plans that the practice may want to consider not accepting in the future. Another example is to analyze all payers for a given service performed in the practice to determine if that service is a good use of the practice's clinical time. This analysis provides one aspect of whether or not the practice should consider continuing to offer a certain service such as case management of a patient who is receiving a home health service. Of course, the administrator has to weigh services that aren't profitable against any negative impact on overall patient satisfaction but the PM system provides a means of analyzing payment performance.

Most PM systems also offer patient scheduling software that further increases the efficiency of the business aspects of a medical practice. Finally, some PM systems offer an encoder to assist the coder in selecting and sequencing the correct diagnosis (International Classification of Diseases, 9th revision, clinically modified for use in the US or ICD-9-CM) and procedure (Current Procedural Terminology, fourth edition or CPT-4 and Healthcare Common Procedure Coding System or HCPCS) codes. Even when a physician determines the appropriate codes using a "*superbill*," a list of the common codes used in that practice along with the amount charged for each procedure, there are times when a diagnosis or procedure is not listed on the superbill and an encoder makes it efficient to do a search based on the main terms and select the best code. Furthermore, some encoders are packaged with tools such as a subscription to "*CPT Assistant*" that help the practice comply with correct coding initiatives which in turn optimize the reimbursement to which the practice is legally and ethically entitled and avoids fraud or abuse fines for improperly coding.

Clinical and Administrative Workflow in a Medical Office

Several steps are common to almost any medical practice with regards to treating patients and getting reimbursed properly for the services provided. The steps are subdivided based on whether or not the patient has been to this practice previously for any type of service. The first step is to get the patient registered. This can be accomplished via a practice website or by the patient calling the office to schedule an appointment. Figure 3.1 demonstrates typical outpatient office workflow.

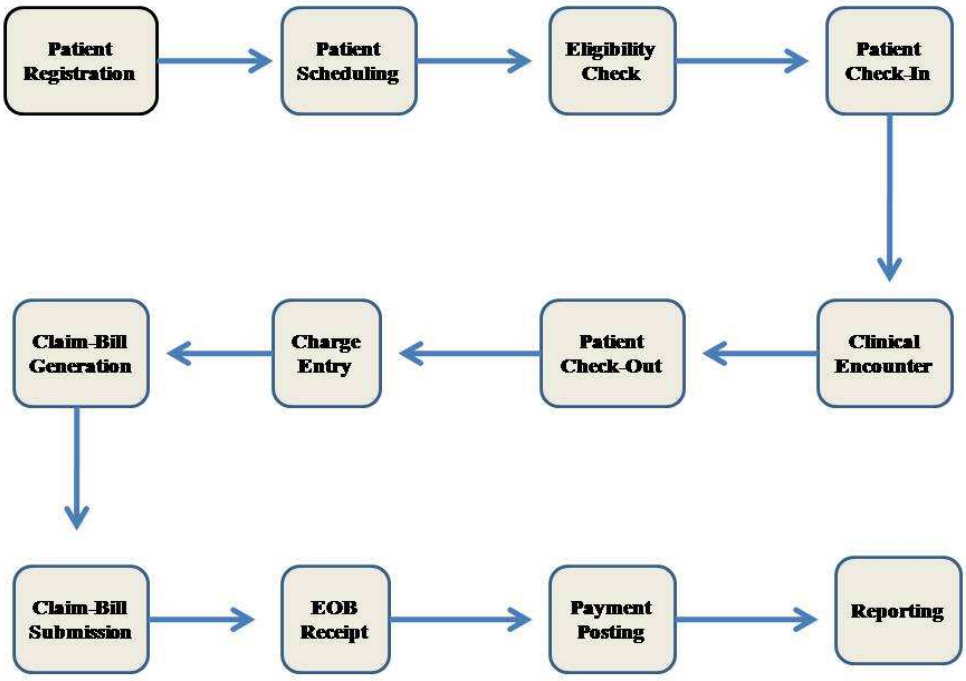

Figure 3.1 Typical Outpatient office workflow (EOB = explanation of benefits)

Patient Registration. This step includes obtaining demographic information, including any healthcare plan or plans the patient has and establishing which member of the patient's household is financially responsible for any balances due either at the time of the visit or after claims adjudication by any healthcare payer(s) the practice agrees to bill for the patient. The patient is then scheduled for an appointment. If the patient had a previous encounter with the physician, the office receptionist simply has to update any changes to the patient information already on file. For a new patient the insurance information must be verified to ensure that the patient is currently covered by a plan accepted by the practice and the planned services are a covered benefit. If not, the patient must be notified in advance of the visit to determine if they are willing to accept full financial responsibility for the services (i.e. full payment then attempt to get reimbursement from their healthcare plan on their own) or cancel the appointment and find a participating physician. If a practice offers web-based patient registration, there are some choices ranging from designing the website and all applicable online forms internally to contracting with a forms services company. Based on the amount of money the practice is willing to spend, a forms company offers basic forms design for use on the practice's own website. Alternately, they can subcontract to use the company's server and website for forms design, updating, processing and transmitting information to the practice's EHR or PM system. See Medical Web Office services for a sample range of forms and communications services available for medical practices.[2]

Patient Encounter. The patient checks in for the scheduled visit. If already established with the practice the receptionist simply verifies/updates the patient information. If the patient is new, and the data gathered to schedule an appointment was obtained via telephone, the patient is asked to complete a registration form and provide a copy of his or her insurance card(s). Any information not previously obtained is keyed into the computer system for use by the PM system and the source document is added to the paper medical record, if applicable. Scanning the information is an option with an EHR. Most practices that have a PM system that is integrated with an EHR can scan the documents (including bubble sheets completed by the patient at time of registration) into the system once and the information is posted to the appropriate places in both the EHR and the PM system. Sometimes the data that is used by both the EHR and the PM software, such as patient name, is saved to a common database in an integrated system. Other times, however, the shared data is communicated electronically between the EHR and the PM system even though the databases are separate. It is important to know that when the systems have a shared database, this database only contains the part of the clinical record that is used to obtain reimbursement such as the patient demographics, diagnoses and procedures, dates of service, etc. However, the purely financial information is only found in the PM system – such as amount billed and amount paid or information about health plans. This is because it is not advisable to combine the business aspects of health information with clinical aspects. What procedure is done on a given date and the diagnosis that justifies the medical necessity of a procedure is both clinical and financial but how much the procedure costs and how much the patient paid out-of-pocket, etc. is purely financial.

Clinical Aspects of Patient Encounter. The patient is generally first seen by a nurse, to have vitals taken, collect blood and urine samples, if needed, and update the patient's subjective history. The patient is then examined by the physician who takes additional history and completes the objective physical exam and updates the clinical notes in SOAP order – Subjective, Objective, Assessment and Plan. In a paper system, the physician dictates either during the visit or as soon afterward as possible and a transcriptionist creates a paper copy of the notes. Alternately, some physicians use voice recognition technology to dictate directly into a laptop or other device then print out the report generated by the software to file in the paper record. For a sample of a full range of voice recognition software that can be used as a standalone product for creating a paper document or that interfaces with electronic health records, visit Nuance's website.[3]

In an EHR system clinicians have several options for inputting patient information into the clinical record. They can use voice recognition software, standard dictation or templates. This can be accomplished on a PC or in a wireless mode with a tablet PC or PDA. For example, an EHR is formatted with physician workflow in mind and then, customizable by each individual physician to optimize efficiency based on specialty and personal preferences. The customization "initially takes time and patience but is well worth the effort in a practice that sees a lot of patients daily with the same symptoms such as an ear infection for a pediatrician."[4] Therefore, when the physician is face-to-face with the patient, the EHR would have already been started for that encounter by a nurse or other physician extender who would have entered the patient's chief complaint, vital signs and possibly any updates to the patient's subjective history (the subjective portion of the SOAP notes).

The physician will continue building the encounter notes by using a series of drop-down menus to indicate body systems examined, tests performed, tests or prescriptions ordered, (the objective portion of the SOAP notes), the assessment and the plan. Each selection made by the physician adds to the clinical notes. Clinical notes are a good example of data that is maintained in the EHR but not shared with a PM system. However, EHRs that use computer assisted coding technology can convert the standardized notes into codes and the codes are used by both the EHR and the PM system. For example, many EHRs can run the office notes through logic to assign CPT evaluation and management (E&M) codes based on either the 1995 or 1997 guidelines. The EHR system can pass these codes plus many ICD-9-CM codes over to integrated (same vendor) or interfaced (different vendors) PM system when the systems are compatible. However, a person responsible for correct coding and billing, must still verify that all applicable codes were brought over to the PM system, add any codes that the system did not assign automatically since it does not completely code all diagnoses and procedures for every encounter, and scrub the codes which means to link the diagnoses to the correct procedures to justify medical necessity and check for obvious errors in order to get them ready to submit as claims to payers. The physician then discharges the patient with any applicable drug samples and patient education literature. Any lab samples are sent to the lab and, if the patient needs a prescription and the practice uses e-prescribing, a prescription is sent from the EHR to the pharmacy electronically or via Fax. If not, the patient is given a paper copy of the prescription.

After the Patient Encounter. The patient is discharged after a receptionist collects any money due and schedules any follow-up visits. If the practice has chosen this feature, the EHR can interface with the PM system scheduler so the physician can schedule a follow-up visit and the patient can take home a printout of the office notes, any education material, the next appointment, plus a paper copy of physician orders or prescriptions for facilities not linked with the EHR. In a standalone PM system, the charges are entered, often from a superbill but sometimes the services are coded from the information in the medical record. In an integrated PM with EHR system, the information needed is sent directly from the EHR to the PM system and a claim is built as described above. The claims are sent electronically in all but rare cases but they are sent in cycles so once the PM system is updated, the claim is in queue waiting for transmission to a clearinghouse or directly to the payer such as Medicare. Once the claim is sent, the payer electronically (again, there are some exceptions in which the practice will actually get a paper check in the mail) sends a remittance advice (RA) containing the details for each charge paid or denied in that cycle. The RA contains an explanation of benefits (payments, denials, denial reason, reduced payments and reasons, patient responsibility, whether or not the claim was sent automatically to a secondary payer, etc.) for each charge by patient. The money is electronically deposited into the practice's account. The payer generally mails a paper copy of each individual explanation of benefits to the patient. Billing personnel also have to follow-up when a person has more than one payer, to determine that the claim was transmitted to the appropriate secondary payer. If there is still a balance after the biller has applied payments and

written off any charges in excess of the allowed amount for a particular payer, the system moves the balance into a queue to await patient billing. The biller is also responsible for tracking claims and initiating the collections process if a balance due by the patient is not paid in a timely fashion. Daily reports are run and verified to ensure deposits match, all patients who were seen that day have charges in the system etc. There are both routine reports (daily, weekly, monthly and end-of-year) and ad hoc reports used by the practice.

Telephone calls in a Medical Office. Calls to the practice may be for various reasons from cancelling an appointment to asking if the doctor can see a patient who does not have an appointment. The calls should be prioritized into categories for emergency (in which the practice should advise the patient to hang-up and dial 911 and then confirm the patient is capable of doing that before disconnecting), urgent or non-urgent. Many EHR systems enable the message-taker to route the call directly to the intended recipient instead of having to take a paper message. In this case, protocols exist in which the person answering the phone can take certain actions or make some decisions. For example, the receptionist may be able to determine if outside lab results have been received by the practice or not. If they have, the receptionist can route a message directly to the appropriate clinician requesting the patient be called regarding the results. In more urgent cases, a patient may have a non-emergency, but urgent condition and request to be seen that day. The receptionist may be able to schedule that person in and tell them when to arrive. If the receptionist is uncertain, he or she may route an urgent message to the most appropriate clinician for a decision about whether the patient can be seen that day. The messages go directly to the recipient's attention and may be color-coded to highlight urgent versus non-urgent.[5-6]

Practice Management Systems and EHRs

When the administrators of a medical practice commit to the conversion of paper-based or hybrid records to an electronic health record system, they should strongly consider converting their existing practice management system to one that is integrated with the EHR they chose. Although this strategy means a higher initial investment of both time and money many practices report that part of their overall success with implementing an EHR with a PM system is due to the increased efficiency and accuracy of the billing process when the systems are integrated. One alternative to discontinuing an existing PM system – especially one that works very well and that everyone in the office who uses it is comfortable with, is to find a reputable EHR vendor that offers interface capabilities with your existing PM system vendor. For example, Eclipsys (formerly MediNotes), has a list of PM systems with which their EHR interfaces. One potential setback is anytime a vendor upgrades its software, the interfaces have to be tested and both vendors may need to get involved.

As mentioned in the Electronic Health Records chapter, formal studies of return on investment (ROI) for an EHR in medical practices are very limited at this time and although some of these studies mention how many of the practices surveyed implemented an EHR in conjunction with an integrated PMS, they don't differentiate the results as to the impact on ROI of an integrated EHR/PM system versus a standalone EHR project.

There are some testimonials and customer information pages available on many of the vendor websites that discuss success stories of EHR implementation in which some of the cost savings were realized by the integration of the EHR with a PM system. Some of these websites also list the ROI based on an integrated EHR/PM system. [7-8]

In March of 2008, the Medical Society of New York reported on the experience of a solo, internal medicine practice in identifying, purchasing, implementing and maintaining an EHR with a PM system. Some of the highlights from this article include:

- Chose in-office server over application service provider (ASP) because it was more affordable since the practice already had old computers that could be used as workstations and they did not already have business-grade broadband Internet service provider necessary for an ASP arrangement
- Chose to pay a monthly subscription fee to use the EHR/PM software because it was less expensive than purchasing software and hardware required. Lease agreement was approximately $400 per month for software and off-site HIT support
- HIT vendor provided most of the on-site technical support during the first three months
- Chose the EHR from same vendor as PM because, "*to run an efficient office, the two systems should be totally compatible and ideally share the same database."*
- The criteria most important to Dr. Volpe included: perform the same functions as a paper record only better; affordability; navigability for all users between both the EHR and the PM systems; adaptability -the records and templates for information were easily modified and customized as patient information and practice needs changed; track record of vendor; ease of data entry; tight security and, CCHIT certification
- The transition from paper was easy (by comparison) for the doctor and his staff because they had already used an e-prescribing system and a patient web portal. They transitioned from the old billing system to the new PM system gradually over 30-90 days by using the old system for any patient billing that was in-process or occurred before the staff training was complete and then used the new system for all encounters occurring after the staff was trained
- The overall assessment considering the improvement in efficiency, improved patient care and improved claims coding and submission is: "*within one year, Dr. Volpe had paid off the cost of his new hardware, his office had returned to full productivity, and he was earning over $30,000 more than he had the year before, due primarily to reduced overhead costs (space for paper records has been converted to an additional exam room, for example). He, his family, his staff and his patients all love the new system*[9]
- According to a recent newsletter offered by the Health Information Management Systems Society (HIMSS), "*A tool was recently launched to measure the healthcare industry's move from paper-based processes to electronic business applications. Called the US Healthcare Efficiency Index, this tool is intended to raise awareness about the cost savings that can be achieved by increasing the adoption of electronic business processes. One third of respondents believed that the largest cost savings would come in the area of claims submission. Nearly half of respondents that work for a healthcare provider organization reported that they submitted claims payments electronically. A similar percent also reported that their organization submitted claims eligibility and claim remittance advice transactions electronically. Another potential area of cost savings would be to have claims payments issued via direct deposit."* [10]

Practice Management System Examples

There are more than 200 practice management systems on the market with a variety of PM features to include integration with an EHR and the availability as both a client server model and/or an ASP model. In Table 3.1 we have included a list of the better known vendors who offer a combined EHR-PM that is CCHIT certified and available in the ASP model. In the resource section we will direct you to methods to search all available PM systems.

Resources

Although there is very little written about the merits and limitations of practice management systems, we can direct you to several helpful resources. A 2009 monograph by the California HealthCare Foundation "Practice Management Systems for Safety-Net Clinics and Small Group Practices: A Primer" discusses how important PM systems are for safety net clinics but also provides an excellent overview on the subject. [11]

For prospective purchasers of PM systems and/or EHR systems several resources are worth mentioning

- Capterra is a web site that includes a search engine with filters for operating systems (platform), number of users, PM features, inclusion with EHRs, location (example USA) and annual revenue. Over 200 products are included with hyperlinks to the individual web sites, demos and tours [12]
- EHRScope is a search engine for EHRs but includes the ability to filter the search for EHRs that include PM systems, as well as differentiate between systems are are web-based or client-server based. Without filtering, 342 EHRs are included [13]
- "Selecting a Practice Management System" is a monograph by the American College of Physicians. Members can access this resource that focuses how to go about selecting a PM system, in terms of the steps that are necessary prior to purchase [14]
- "Medical Practice Management Buyer's Guide" is a May 2008 web-based resource that includes pricing and tips before purchase. [15]
- The Online Consultant is a fee based generator of "requests for proposal" (RFP). In the case of PM systems they generate detailed questions about price and functional requirements. Once the RFP is complete they offer the ability to graph and create comparison reports between vendors. Charge is $695 for PM RFP [16]

Table 3.1. EHR-PM integrated systems that are CCHIT approved and available as an ASP model

EHR-PM System	Web site	Features
ABELMed v8	www.abelsoft.com	ASP available
Allscripts MyWay PM Allscripts Professional PM	www.allscripts.com	ASP available. Small-medium practices
Athena clinicals	www.athenahealth.com	Only ASP. Can outsource the billing service
Cerner PowerWorks	www.cerner.com	ASP available. Small-large practices
e-MDs Solution Series	www.e-mds.com	ASP available
eClinicalWorks	www.eclinicalworks.com	ASP available. Small-large practices
Eclipsys PeakPractice	www.medinotes.com	ASP available
GE Centricity Practice Solution	www.gehealth.com	ASP available. Medium-large practices
iMedica Prima	www.imedica.com	ASP available.
NextGen Healthcare	www.nextgen.com	ASP available.
Purkinje Care Series Plus	www.purkinje.com	ASP available.
Sage Intergy V 5.5	www.sagehealth.com	ASP available
Waiting Room Solutions	www.waitingroomsolutions.com	ASP available. Covers 26 specialties

Key Points

- Many medical practices are struggling with implementation of EHRs and how to determine the return on investment (ROI) for a new integrated PM system
- As reimbursement methodologies become increasingly more complex and tied to quality measures, it is of utmost importance to ensure a medical office has the tools to obtain full payment to which the practice is legally and ethically entitled by collecting all of the appropriate data that justifies medical necessity and compliance with quality guidelines
- Practitioners not only have to provide high quality and safe patient care but they must do so as efficiently and effectively as to remain competitive

Conclusion

There are dozens of options for ambulatory care practices to investigate before converting to a robust electronic health record system that is fully integrated with, or interfaced with, a comprehensive practice management system. The chapter in this book on electronic health records discusses the steps a practice can take to identify the best overall electronic health record and practice management system based on factors such as size and type of practice, degree to which each physician supports the transition, information technology preferences (servers, technical support, purchase versus lease etc.), priority of various features, projected return on investment (ROI) and other considerations. The practice management piece fits in nicely with the overall EHR selection, implementation, training and maintenance process but should be included from the start rather than starting the selection and implementation piece after the EHR system is already in place. Although not every practice that implemented an EHR/PM system agrees, the combination of functionality between the clinical aspects and the business aspects of medical practice is considered the ideal future direction by many physicians and administrators who have had their combined systems long enough to enjoy an excellent return on their investment, improved efficiency, improved quality of care documentation and reimbursement.

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4

Health Information Technology Interoperability

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Learning Objectives

After reading this chapter the reader should be able to:

- Identify the need for and benefits of interoperability
- Describe the concept of Health Information Organizations and how they fit into the Nationwide Health Information Network
- State the most important data standards and their role in interoperability
- Describe the importance of data security and privacy as part of HIPAA

Health information technology (HIT) interoperability means that electronic applications, devices or systems are able to exchange health-related information. Interoperability is a critical element in the future success of health information exchange (HIE) at the local, regional and national level. As an example, patient data within an electronic health record is interoperable if it can be shared with another computer or information network. If disparate data sets can understand terminologies automatically, without human intervention, then it is referred to as semantic interoperability.[1]

Interoperability is important to all healthcare organizations, particularly the federal programs such as Medicare/Medicaid for several reasons. The federal government determined that health information exchange was essential to improve: the disability process, continuity of medical care issues, bio-surveillance, research and natural disaster responses. Electronic exchange of data should result in faster and less expensive transactions, when compared to standard mail and faxes. In order to accomplish this goal multiple partners would need to be able to communicate using data standards discussed later in this chapter. The end result has been that the federal government has been a major promoter of HIT interoperability.[2]

The Commission on Systemic Interoperability (CSI) was one of the earliest initiatives to evaluate interoperability. It was composed of fourteen members tasked with outlining how to achieve universal interoperable electronic health records. Its much awaited report was published in 2005 with the following recommendations:

- **Adoption**. The federal government should develop incentives for physicians and insurers that include grants and pay for performance initiatives. They should also work to revise or eliminate legal barriers such as the Stark and Anti-Kickback laws. Gaps in health IT adoption should be identified and remedial policies should be developed. The shortage in health IT manpower needs to be addressed and corrected. Lastly, the public needs to know that interoperability will ultimately improve the quality of medical care and patient safety
- **Interoperability.** There is a need to certify health IT products in terms of functionality, security and interoperability. Data standards must be developed with the help of the

American Health Information Community (AHIC) and the National Committee on Vital and Health Statistics (NCVHS). The AHIC should require HIPAA to cover privacy specific for HIT. Also needed were standards for labels and packaging. The AHIC should establish a phased-in approach for an interoperable drug record for every citizen by 2010

- **Connectivity**. National standards for patient authentication and identity need to be developed. The Department of Health and Human Services should work with other agencies to fund a national health information network. There should be criminal punishment for privacy violations. Patients should not be discriminated against based on health data[3-4]

Many of the recommendations made by the CSI are now a reality. Additional federal panels and committees that are involved with HIT interoperability have been created since 2005 and are discussed in chapter 1.

This chapter will discuss three major aspects of HIT interoperability: 1) The Nationwide Health Information Network (NHIN) and Health Information Organizations (HIOs) 2) Data standards and 3) HIPAA regulations.

The Nationwide Health Information Network (NHIN) and Health Information Organizations (HIOs)

Definitions

In 2008 the National Alliance for Health Information Technology (funded by ONC) released a new set of definitions that would help clarify the ambiguity of several HIT terms:

Health Information Exchange (HIE) is the "*electronic movement of health-related information among organizations according to nationally recognized standards*".

Health Information Organization (HIO) is "*an organization that oversees and governs the exchange of health-related information among organizations according to nationally recognized standards*".

Regional Health Information Organization (RHIO) is "*a health information organization that brings together health care stakeholders within a defined geographic area and governs health information exchange among them for the purpose of improving health and care in that community*".[5]

Note that the term RHIO is inexact because HIOs do not have to be regional; they can include only one city or an entire state. Furthermore, HIOs are being created to just exchange health information for Medicaid patients or uninsured populations. In keeping with these new definitions we will use the acronym HIO when addressing generic health information organizations and RHIO when addressing specific defined HIOs. We will also use HIE to describe the movement or exchange of health information.

Background

In April 2004 President Bush signed Executive Order 13335 creating the Office of the National Coordinator for Health Information Technology (ONC) and at the same time calling for interoperable electronic health records within the next decade.[6] How that would be accomplished was not stated or known at the time of the executive order.

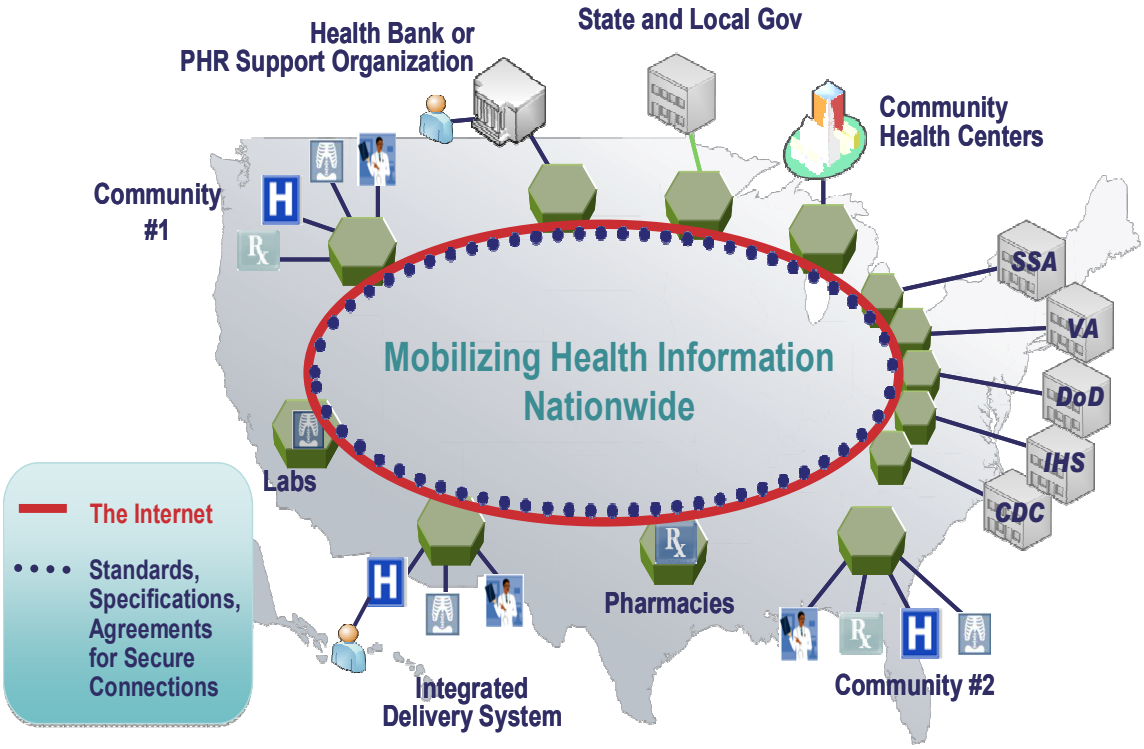
In November 2004 ONC sent out a "*Request for Information*" (RFI) as to how the Nationwide Health Information Network (NHIN) should be established. In particular, they wanted to know how the NHIN would be governed, financed, operated and maintained. Five hundred and twelve

responses were received and published in a summary paper. The June 2005 report concluded that the NHIN should:

- "*Be a decentralized architecture built using the Internet linked by uniform communications and a software framework of open standards and policies*
- *Reflect the interests of all stakeholders and be a joint public/private effort*
- *Be composed of public and private stakeholders who oversee the determination of standards and policies*
- *Be patient centric with sufficient safeguards to protect the privacy of personal health information*
- *Have incentives to accelerate deployment and adoption of a NHIN*
- *Enable existing technologies, federal leadership, prototypes and certification of EHRs*
- *Address better refined standards, privacy concerns, financing and discordant inter and intrastate laws regarding health information exchange*"[7]

The decision therefore was made to have a decentralized "*network of networks*" that would eventually connect to create the NHIN (Fig.4.1). That also meant that there would not be a centralized data repository of patient information. In order to create the NHIN it would require hundreds of HIOs to be interoperable with thousands of individual healthcare entities.

Executive Order 13410 (August 2006) required federal agencies that dealt with health information to select systems that met national interoperability standards. This provided new guidance regarding interoperability for federal agencies and contributed one more building block



towards the creation and deployment of the NHIN.[8]

Figure 4.1 NHIN Model (Courtesy ONC)

In 2006 the National Coordinator for Health Information Technology made the following suggestions as to how HIOs might proceed:

- Leverage the Internet as an infrastructure; think web-based
- Build upon existing successes; take advantage of any existing infrastructure
- Have a realistic implementation plan; build incrementally or by phases or modules
- Develop strong physician involvement; involve medical schools and medical societies
- Obtain hospital leadership commitment; much of the information to be shared comes from hospital IT systems
- Do not exclude any stakeholders; HIOs should consist of multiple types of healthcare organizations
- Seek inclusion of local public health officials; the goal is to also develop a public health information network or PHIN
- Obtain support from the business community; vendors who have networking experience will be valuable partners
- Establish a neutral managing partner; a commission or network authority[9]

In 2005 ONC awarded contracts to develop prototype architectures of the NHIN to four contractors (Accenture, Computer Sciences Corporation, IBM and Northrop Grumman). The results reported in January 2007 discussed the important issues of security, data standards and technology. The contractors had to support the "*use cases*" of EHR-lab use, consumer empowerment and biosurveillance. ONC required that the NHIN must interface with electronic health records, personal health records, health information organizations and other organizations that dealt with secondary use of data like public health and research. Clearly, those that chose to participate in the NHIN would have to accept uniform standards, services and requirements.[10] Specifics of the four different NHIN architectures can be found in an extensive monograph published by Gartner in May 2007.[11]

In June 2007 the Department of Health and Human Services released a request for proposal (RFP) to participate in phase 2 known as "*Trial Implementation*". Contracts totaling $22.5 million were awarded to nine HIOs in October 2007 as part of the NHIN Cooperative: CareSpark, Delaware Health Information Network, Indiana University, Long Beach Network for Health, Lovelace Clinic Foundation, MedVirginia, New York eHealth Collaborative, North Carolina HealthCare Information and Communication Alliance, Inc and West Virginia Health Information Network. In addition, the CDC awarded contracts to study the use of HIOs to support public health information exchange and biosurveillance.[12]

In February 2008 ONC announced that 20 federal agencies would connect to the NHIN, as the so-called "*tenth partner*". Individual participants in the trial implementation are referred to as Nationwide Health Information Exchanges or NHIEs. This overall effort is known as the NHIN-Connect Gateway (previously referred to as NHIN-C). It is interesting that one of the federal agencies was the Social Security Administration that benefits greatly from HIT because it normally requests 15-20 million records yearly from clinicians. The Department of Defense and Veterans Administration jointly represent the largest NHIN participant with active patient populations. The other government agencies involved are the National Cancer Institute and the Indian Health Service. Additional organizations that were added in the 2008 time frame include the Cleveland Clinic, HealthLINC, Community Health Information Collaborative, HealthBridge, Kaiser Permanente and Wright State University.

In late 2008, HHS hosted a national demonstration of phase 2 of the NHIN, wherein the aforementioned participants exchanged live health information (using test patient data).

Specifically, participants tested the ability for a health entity to query a record, compile a patient summary record and send that information back to the person or entity that requested it. The standard used for interoperability by the NHIN was the C32 specification for Continuity of Care Documents (see next section on data standards), that included patient registration and medication information.[13-14] As of mid-2009, there are 19 NHIN trial participants. In summary, the NHIN strategy is to establish cross-agency collaboration, develop the gateway tools and lastly participate in trial implementations.

One impediment to rapid NHIN progress is the need for a common data use and reciprocal sharing/support agreement (DURSA). This is important because the NHIN will have civilian partners from multiple states as well as federal partners. The process of achieving a common trust on how data will be used across all participants of the NHIN takes time and has multiple HIPAA implications. HHS has released a tool kit to help HIOs write DURSAs.[15] Another similar concern is whether private partners will have to adhere to regulations based on the Federal Information and Security Management Act (FISMA). This would attach burdensome regulations on the private sector that could slow interoperability.[16]

The Social Security Administration was the first federal agency in 2009 to use the NHIN to connect to MedVirginia HIO in order to request patient information for disability determinations. The time to retrieve the necessary information has been less than one minute, in most cases, a huge improvement over prior paper-based average of 65 days to process a claim. Given the fact that the majority of veterans and active duty service members receive medical care outside their respective systems, it is likely we will see VA and DOD trials in the near future.[17-18]

The Federal Health Architecture Group (FHA), part of the ONC as well as an eGovernment Initiative under the Office of Management and Budget (OMB), released the code for an open-source software NHIN gateway known as CONNECT into the public domain in March 2009. The intent of this release was to incentivize and promote adoption of the NHIN by releasing a basic "reference implementation" of NHIN standard services. With this tool, federal agencies can use the same gateway to access the NHIN as opposed to each agency developing their own. CONNECT utilizes service oriented architecture (SOA) on a Java-based platform (Fig 4.2).

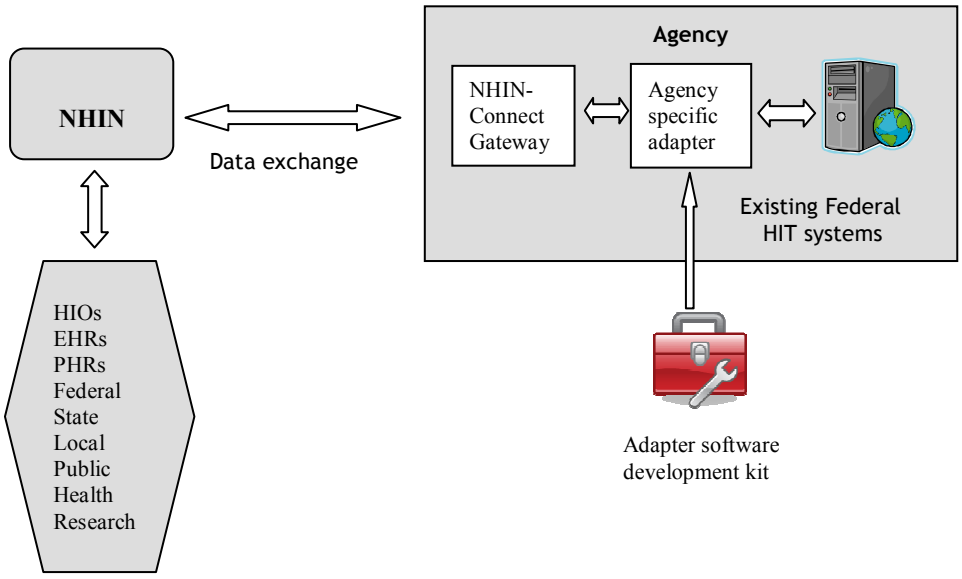


Figure 4.2 Federal Gateway Overview (Adapted from Federal Health Architecture) [20]

CONNECT Gateway consists of three elements:

- **NHIN Gateway** implements the core services such as locating patients at other health organizations within the NHIN and requesting and receiving documents associated with the patient. It also includes authenticating network participants, formulating and evaluating authorizations for the release of medical information and honoring consumer preferences for sharing their information
- **Enterprise Service Component (ESC)** provides enterprise components including a Master Patient Index (MPI), Document Registry and Repository, Authorization Policy Engine, Consumer Preferences Manager, HIPAA-compliant Audit Log and others. This element also includes a software development kit (SDK) for developing adapters to plug in existing systems such as electronic health records to support exchange of health information across the NHIN.
- **The Universal Client Framework** enables agencies to develop end-user applications using the enterprise service components in the ESC[19]

Web Services and Service Oriented Architecture

Because HIOs are based on Internet-based web services, we are adding a short primer on the subject for better understanding. Prior to the advent of the Internet, disparate business and health care entities were not able to exchange data; instead data resided on a local PC or server. *Web services* are platform independent applications that communicate with other web based applications/services over a network (Internet). Web services reduce the cost of converting data with external partners. In order to accomplish this you need standards and service oriented architecture (SOA) that is basically a collection of services. The most common standards are HTTP as the Internet protocol and XML as the programming language (covered later in this chapter). Web services require three basic platform elements:

- **SOAP** (Simple Object Access Protocol): a communication protocol between applications. It is a vendor independent format (XML based) for sending messages over the Internet. It re-uses the HTTP for transporting data as messages
- **WSDL** (Web Services Description Language): a XML document used to describe and locate web services
- **UDDI** (Universal Description, Discovery and Integration): a directory for storing information about web services, described by WSDL. UDDI communicates via the SOAP protocol

So how does this work? There is a service requester seeking a web service. You search using a search engine that uses a structured language. SOAP is the method for sending messages, UDDI looks up the service in a directory (like the yellow pages) and WSDL describes the services. Once the service provider is located, a SOAP message can be sent back and forth between the service requester and service provider. In reality, a service provider can also be a service consumer so it is helpful to view web services like the "*bus*" in a PC, where you plug in a variety of circuit boards. In addition, you need a Master Patient Index (MPI) to locate and confirm patients and a record locator service (RLS). You will also require gateways (a network point that acts as an entrance to another network) and adapters (software that connects to applications).[20-22] For examples of the four prototypical NHIN web services architectures we refer you the monograph by Gartner.[11] Another valuable recent article *Improving Performance of Healthcare Systems with Service Oriented Architecture* describes how SOA is the logical backbone for HIOs and electronic health records.[23]

The last resource for understanding SOA and healthcare was published in March 2009 by the California HealthCare Foundation, *Lessons from Amazon.com for Health Care and Social Service Agencies.*[24]

Health Information Organizations today

The NHIN is a national initiative and strategy to link together disparate federal and non-federal healthcare entities so Americans can have an interoperable health record in the next decade. One of the entities most likely to connect to the NHIN will be health information organizations (HIOs) that are appearing across the nation.

Most HIOs begin with simple processes such as test results retrieval, electronic claims submission, e-prescribing, simple order entry and much later electronic health records. The planning phase generally takes several years and necessitates grant support. Several models of health information exchange data storage have appeared:

- **Federated**—means that data will be stored locally on a server at each entity such as hospital, pharmacy or lab. Data therefore has to be shared among the users of the HIO
- **Centralized**—means that the HIO operates a central data repository that all entities must access
- **Hybrid**—a combination of some aspects of federated and centralized model

The following table outlines some of the pros and cons of the federated and centralized models.

Table 4.1 Pros and Cons of RHIO models (Adapted from Scalese [25])

	Centralized	Federated
Pros	• Simplicity • Data appearance is uniform • Faster access to data • Easier to create because it is web-based	• Greater privacy • Good examples exist • Buy-in may be easier if data is local
Cons	• Higher hardware costs • Higher operating costs • More difficult with very large HIOs	• Data display might not be uniform • Data retrieval delays from others

In order for a HIO to succeed, multiple participants will need to be involved in the planning phase. Examples would be:

- Insurers (payers)
- Physicians
- Hospitals
- Medical societies
- Medical schools
- Medical Informatics programs
- State and local government
- Employers
- Consumers
- Pharmacies and pharmacy networks
- Business leaders and selected vendors
- Public Health departments

Multiple functions need to be addressed by a HIO according to the consulting group HealthAlliant such as:

- Financing: it will be necessary to obtain short term start up money and more importantly a long term business plan to maintain the program
- Regulations: what data, privacy and security standards are going to be used?
- Information technology: who will create and maintain the actual network? Who will do the training? Will the HIO use a centralized or de-centralized data repository?
- Clinical process improvements: what processes will be selected to improve? Claims submission? Who will monitor and report the progress?
- Incentives: other than marketing what incentives exist to have the disparate forces join?
- Public relations (PR): you need a PR division to get the word out regarding the potential benefits of creating a HIO
- Consumer participation: in addition to the obvious stakeholders you need input from consumers/patients[26]

The expectation is that HIOs will save money once they are established. It is presumed that the network will reduce office labor (faxing, etc) and duplication of orders. Table 4.2 shows a model of predicted savings from the Center for Information Technology Leadership (CITL).[27] Many people feel that insurers are likely to benefit more from HIE than clinicians. It is important to point out that these are projected models and the predictions may be overly optimistic and not applicable to every HIO. It is clear that one of the benefits of health information exchange is more cost effective electronic claims submission. As reported by the Utah Health Information Network, a paper claim costs $8, an electronic claim $1 and the charge by the HIO of 20 cents; therefore a savings of $6.80.[28]

Table 4.2 Projected savings (in billions) from HIO creation (Adapted from CITL)

	Payer	Clinician	Lab	Radiology	Pharmacy	Public Health	Total
Savings	$21.6	$24	$13.1	$8.2	$1.3	$0.1	$68.3

Health Information Organizations should not be an abstract concept and should reflect actual needs of a region or community and focus on improved patient safety. The New York Clinical Information Exchange conducted an interesting survey of more than 200 emergency room physicians to determine both the perceptions and information needs of clinicians. The results might not apply to rural areas or other specialties but they are still of interest. The following are some of the conclusions:

- 76% of physicians were not familiar with HIOs
- 39% of respondents thought that more than half of patients would benefit from this innovation
- 66% of ER physicians stated that more than half of their attempts to retrieve records were unsuccessful
- The average time to receive outside records was 66 minutes
- 98% believed that HIOs would benefit the field of medicine

- A majority thought that medical errors would decrease as would the number of tests ordered with the creation of a HIO
- The top test results requested were EKGs, discharge summaries, medications, labs and x-rays
- Most were happy with just x-ray reports and not the actual image, with the exception of plain films and CT scans[29]

There are open-source tools available for evolving HIOs. The California HealthCare Foundation donated server software for the master patient index and records locator. The tools are available through Open Health Tools, an international consortium. This technology assists the EHR vendors attending the annual Connectathon held at the annual HIMSS conference.[30-31]

It is important to note that only about a decade ago Community Health Information Networks (CHINs) began springing up across the US. Approximately 70 pilot projects were created but all failed and were terminated.[32] In spite of this shaky history, HIOs are again on the horizon. Currently in the United States there are about twenty HIOs actually exchanging clinical information and about two hundred in the formative stages. It is unknown how many started and failed. The Santa Barbara County Care Data Exchange was a high visibility RHIO that folded in March 2007 due to legal, technological and financial issues.[33] An excellent monograph describes the lessons learned from this project.[34] The Pennsylvania RHIO also closed in 2007 due to lack of money in the short and long term.[35]

Adler-Milstein et al surveyed every known RHIO in the United States to determine its status and functionality. They concluded the following:

- Of the 138 RHIOs identified about 25% were defunct
- 54% were in the planning phases
- Only about 20 RHIOs were actively exchanging information
- 85% exchanged test results and 70% exchanged inpatient data and medication history
- Clinical notes and consultations were offered by 50%
- More than 50% of RHIOs reported moderate dependency on transaction or subscription fees for support
- Insurance companies (payers) and pharmacy organizations were partners, but rarely shared lab results, etc[36]

This same group updated their survey in June 2008 and published their results in the March/April 2009 issue of Health Affairs. They concluded:

- There were now 44 operational HIOs of the 131 surveyed
- Most HIOs in the planning phase in 2007 failed to become operational
- Most HIOs were not able to sustain themselves financially from revenue generated from information exchange
- Most operational HIOs had very limited functionality[37]

The eHealth Initiative's *2008 Annual Survey on Health Information Exchange: State of the Field.* According to their survey 42 RHIOs (up from 32 in 2007) were fully operational and exchanging data. They divided respondents into 7 levels of operational maturity. They concluded the following:

- 69% of the fully functional exchanges report reductions in health care costs
- 52% of the fully functional exchanges reported health care delivery improvements such as decreased prescribing errors and improved access to lab tests
- 10 HIOs offered disease management services; 6 offered public health reporting; 20 reported emergency room visits
- 50% of respondents noted developing a sustainable business model as a very difficult challenge
- Of note, they recorded that 32% of stake holders participating in HIO governance were associated with health plans[38]

We mentioned in Chapter 1 that the American Recovery and Reinvestment Act included $300 million for health information organizations. It remains unclear how this money will be allocated and its overall impact.

As you will see in the following section, there are many different models of health information exchanges. Most rely on web-based service oriented architecture (SOA) and most link to actual lab and x-ray results. Other payer-based models use claims data and may refer to themselves as having a regional or state electronic health record. In reality they are payer-based personal health records that may be linked to a HIO. They do not offer true EHR functions (patient notes, order entry, etc) as part of their information network.

Examples of Regional Health Information Organizations

Utah Health Information Network. Created in 1993, it has been one of the most financially successful non-profit statewide RHIOs in existence. Figure 4.3 demonstrates the diverse entities associated with this RHIO. Their web site is highly educational and includes a fee schedule.[39]

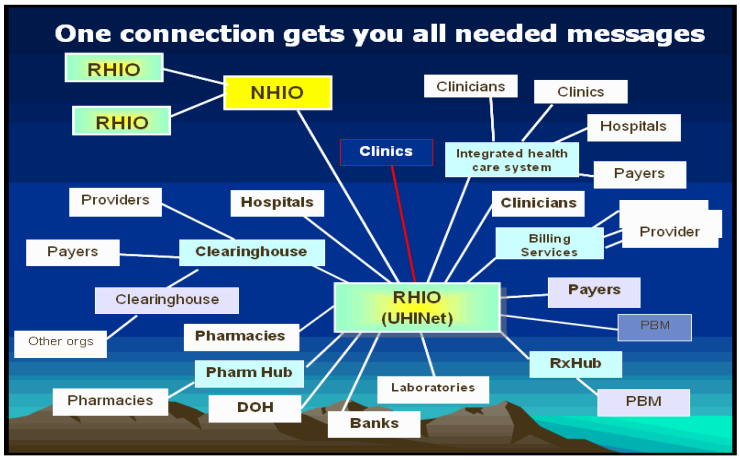


Figure 4.3 Utah Health Information Network (Published with permission)

Kentucky eHealth Network

- Kentucky is the first state to pass a bill calling for the establishment of a statewide RHIO. It will be interesting to see if using a state model instead of regional model is more successful. (Maine, Delaware and Rhode Island also plan to create statewide HIOs)

- The Universities of Kentucky and Louisville will create the Kentucky Health Care Infrastructure Authority. It will be funded by the state, with efforts to obtain federal and private industry grants[40]

Indiana Health Information Exchange. Multiple partners helped create this RHIO in 1999, including the Regenstrief Institute that is part of the Indiana University School of Medicine. The RHIO includes twenty one hospitals from five hospital systems and sixty six percent of outpatient physician offices in the Indianapolis area. It is their goal to eventually cover the remainder of Indiana. They opted to use a centralized approach to storing data in one location. They also wanted to be an example for the rest of the country, employ more workers and create more data for better research. The network includes the state and local public health departments and the homeless shelters. Their HIO offers the following functions:

- Clinical secure messaging known as DOCS4DOCS, that transmits about 1 million messages per month to 5,000 physicians
- Clinical abstracts
- Treatment reminders to physicians
- Physician profiling data
- Results review: radiology results, discharge summaries, operative notes, pathology reports, medication records and EKG reports
- Clinical quality reports
- Research
- Electronic laboratory reports for public health: childhood immunization information and tumor registry
- Syndromic surveillance (looking for syndromes like flu like illnesses to track epidemics or bioterrorism)
- Adverse Drug Event (ADE) detection
- Improvement in integration efficiencies or inefficiencies
- As of August 2007 they deliver clinical results directly into EHRs
- They plan to launch medication reconciliation, diabetes and cholesterol management and breast cancer and colorectal cancer screening. The disease management enhancement is known as QualityHealth First™ and will supply reports, alerts and reminders to clinicians
- Although they are considered one of the most robust of RHIOs with a successful business plan, they have had their share of financial issues[41-44]

North Carolina Health Information Exchange was developed by the North Carolina Healthcare Information and Communication Alliance, Inc (NCHICA). This state-wide innovative HIT organization enjoys the support of over 200 member stakeholders. NCHICA was awarded the NHIN contract for North Carolina. The architecture was created by IBM. Figure 4.4 of the North Carolina HIE Council provides a good look at the types of committees and sub-committees necessary to operate a HIO.[45]

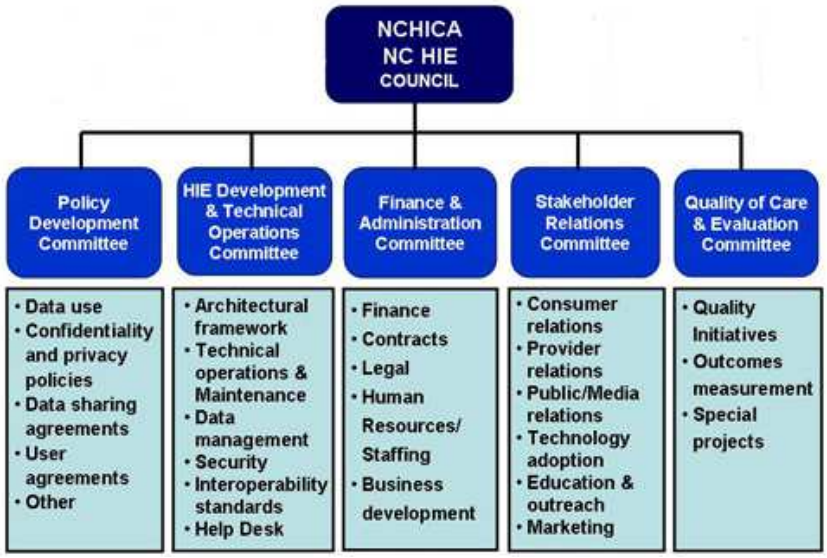


Figure 4.4 NC HIE Committees (Courtesy NCHICA)

SharedHealth. This is an interesting entity that is a large public/private HIO that is Oracle based. They are a HIO for 2.6 million privately insured and Medicaid customers and their system is based on claims data. It should be noted that claims data will only tell you that a test was done and not the actual results and is not available real time. The service is free for participating clinicians. This is not a true EHR in the sense that it does not include either clinical notes or x-ray results. Some have termed this a payer-based health record (PBHR). They do offer integration with known HIOs as one of their features. In addition:

- Their Clinical Health Record (CHR) provides medical histories from claims data: patient demographics, lab results, medication histories, allergies, immunization histories, preventive medicine reminders and electronic prescribing
- In 2009 they added disease management tools
- Patients can also have access to their CHR
- Being used by East Tennessee State University Family Medicine
- In April 2009 they announced that they would release HIO tools to hospital systems in the rest of the nation. Details are on their web site [46]

Availity Health Information Network. This is the first multi-payer based health information exchange. This network uses claims data for patients insured by Blue Cross/Blue Shield of Florida and Humana. The project began in mid-Florida and will likely expand to other areas in the state. The first services offered in 2001 centered around electronic claims submission and later included a patient-physician portal. This initiative may help prevent duplication of tests. The features available for clinicians are known as the Availity Care Profile and include:

- A Continuity of Care Record that shows services rendered, lab and x-rays ordered, diagnoses, procedures performed, hospitalizations and immunizations
- A prescription refill service
- An optional patient portal (RelayHealth) [47]

It is uncertain how rapidly this type of information exchange will catch on and whether new services will be added. Payers such as Blue Cross and Humana stand to gain a lot from electronic

data collection and analysis; but will they add features that assist physicians and not payers? It should also be noted that the following limitations are associated with this model:

- HIO only covers insured patients in the network
- If a patient does not file a claim for a service (pays out of pocket), there will be no record
- A patient can opt-out of sharing data on the HIO
- Patient's employer can opt-out from sharing claims
- Data older than 24 months cannot be retrieved
- There is a lag time between when the test was taken and when the results are posted

South Carolina Health Information Exchange. In 2008 South Carolina launched this claims based HIO for its 800,000 Medicaid recipients. Clinicians have free access to the HIO and at this time they can access medication, diagnoses and procedural histories. In the future they will add lab results, immunizations, discharge summaries, e-prescribing, operative and clinical notes. Data is encrypted and only stored on the network.[48]

Health Information Organization Consultants

HealthAlliant. They are a not-for-profit consulting company involved with all phases of HIOs; planning, formation and financing. So far they have collaborated to create 5 RHIOs:

- Central Appalachian Health Improvement Partnership (CAHIP) that addresses more remote areas of Tennessee and Virginia
- Taconic Health Information Network and Community (THINC) in New York State
- Rhode Island Health Improvement Initiative (RIHII) that also includes an e-prescribing initiative
- A rural Nebraska healthcare access initiative
- Choice Regional Health Network located in Olympia, Washington[26]

Healthvision. This organization hosts web-based solutions for all aspects of building HIOs. Healthvision refers to their HIOs as Connected Healthcare Communities. Currently they host more than 7.7 million patient records for networks in Texas, Connecticut, Maine, California, Virginia and New York. A centralized model of data storage is used.[49]

Health Information Organization concerns

There are multiple concerns surrounding the creation and sustainment of a health information organization. The following are just few of the reported concerns:

- Everyone has a different business model. Is this a public utility with no public funding?
- Who will fund HIOs long term? Insurers? Employers? Consumers? Neither private nor government organizations take full responsibility. The AHRQ funded grants of $18.6 million in late 2005 that went to only four HIOs.[50] What happens when the grant money expires?
- Will we have universal standards or different standards for different HIOs?
- There could be dependence on vendors. BCBS of Tennessee partnered with Cerner who has an EHR product and will receive a per member per month subscription fee [51]

- What should be done with geographical gaps in HIOs and what regions should they cover? Should they be based on geography, insurance coverage or prior history?
- Are poorer cities, states and regions at a disadvantage?
- How can you create a NHIN if multiple HIOs fail and the adoption rate of EHRs is low?
- The federal government is funding NHIN trials with grant money. Will they fund all HIOs to connect to the NHIN?
- What are the incentives for competing hospitals and their CIOs/CEOs in the average city or region to collaborate?
- Who will accredit HIOs, CCHIT or the Electronic Healthcare Network Accreditation Commission (EHNAC)?

Health Information Organization Resources

It can be argued that creating the technology architecture is the easy part in the life of a HIO. Far more time must be spent planning the governance and financing. It is therefore critical that localities do their homework to research the lessons learned from others who have successfully built a HIO. The following are valuable resources:

- *Privacy and Security Solutions for Interoperable Health Information Exchange. Report* for the AHRQ, December 2006[52]
- *Guide to Establishing a Regional Health Information Organization*. Publication by the Healthcare Information and Management Systems Society. 144 page step by step resource. Cost $78 for non-members[53]
- *eHealth Initiative Connecting Communities Toolkit*. This non-profit site offers a wealth of web based information organized into these sections: value and financing module, practice transformation module, information sharing module, technology module and public policy and advocacy module. A resource library and glossary are also part of the toolkit[54]
- *Privacy, Security and the Regional Health Information Organization*. June 2007. California HealthCare Foundation[55]
- *Common Framework: Resources for Implementing Private and Secure Health Information Exchange* is published by Connecting for Health that is part of the Markle Foundation. The Framework consists of multiple documents that help organizations exchange information in a secure private manner, with shared policies and technical standards. Using their protocols a tri-state prototype HIO was created. The Common Framework with 9 policies guides and 7 technical guides is available free for download on their site[56]

Data Standards

According to the Institute of Medicine's 2003 report *Patient Safety: Achieving a New Standard for Care*[57]

> "*One of the key components of a national health information infrastructure will be data standards to make that information understandable to all users"*

In order for EHRs, HIOs and the NHIN to succeed there needs to be a standard language; otherwise you have a "*Tower of Babel*". We use standards every day but often take them for

granted. All languages are based on standards known as grammar. The plumbing and electrical industries depend on standards that are the same in every state. The railroad industry had to decide many years ago what gauge railroad track they would use to connect railroads throughout the United States. The first National Coordinator for HIT believed that standards should come first to promote interoperability of electronic health records and not follow adoption of EHRs. Although we have come a long way towards universal standards, we are not there yet. The progress has been slow in part due to the fact that participation in standards determining organizations is voluntary. [58]

Another important concept to understand about interoperability and data standards is that there are different levels of data (figure 4.5). Paper forms would be considered level 1 with serious limitations, in regards to sharing. Level 2 data could be scanned-in documents. Level 3 data is data entered into a computer that is structured and retrievable, but not computable between different computers. Level 4 data is computable data. That means the data is electronic, capable of being stored in data fields and computable because it is in a format that disparate computers can share and interpret. In order to attain interoperability we need computable data.

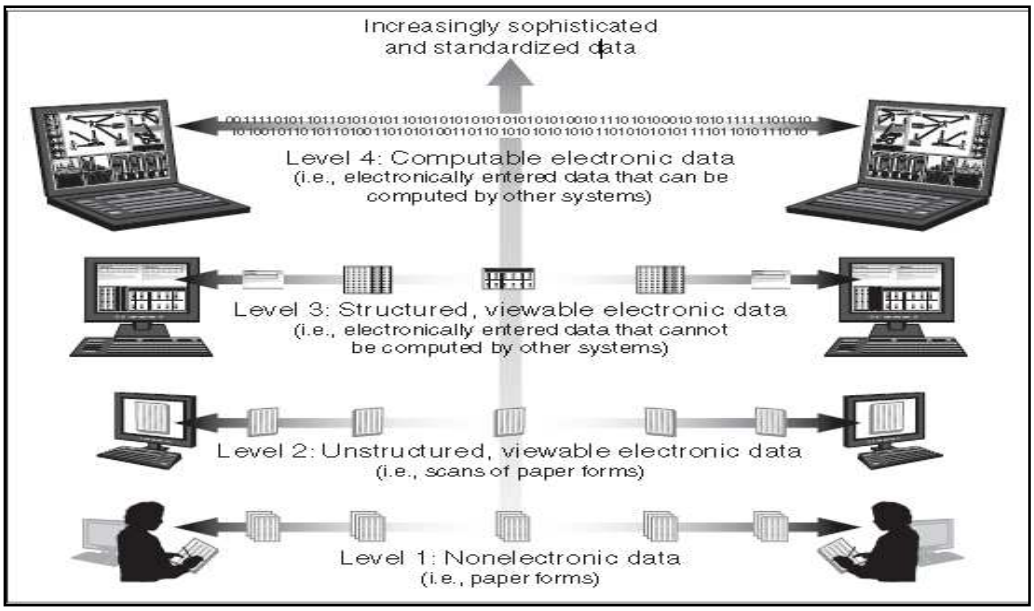

Increasingly sophisticated
and standardized data
Level 4: Computable electronic data
(i.e., electronically entered data that can be
computed by other systems)
Level 3: Structured, viewable electronic data
(i.e., electronically entered data that cannot
be computed by other systems)
Level 2: Unstructured, viewable electronic data
(i.e., scans of paper forms)
Level 1: Nonelectronic data
(i.e., paper forms)

Figure 4.5 Data levels (Courtesy of Government Accounting Office)

The next sections will discuss the major data standards and how the standards facilitate the transmission of data. Not all data standards have been included in the following sections and many standards are still a "*work in progress*".

Extensible Markup Language (XML)

- Although XML is not really a data standard it has become a programming markup language standard for health information exchange. In order for disparate health entities to share messages and retrieve results, a common programming language is necessary
- XML is a set of predefined rules to structure data so it can be universally interpreted and understood
- XML consists of elements and attributes
- Elements are tags that can contain data and can be organized into a hierarchy
- Attributes help describe the element

- Below is a simple example where automobile is the root element and car is the child element. Ford and Chevy are attributes[59]

```
<automobile>
<car id= “Ford” model=”2008”>
    <phone id =”1”> All phone information
        <number>9216604</number >
    </phone>
</car>
<car id=”Chevy” model=”2008>
    <phone id = “2”> All phone information
        <number>9335676</number>
    </phone>
</car>
```

Health Level Seven (HL7)

- A not-for-profit standards development organization (SDO) with chapters in 30 countries
- Health Level Seven’s domain is clinical and administrative data transmission and perhaps is the most important standard of all
- "Level Seven" refers to the highest level of the International Organization for Standardization (ISO)
- HL7 is a data standard for communication/messages between:
    - Patient administrative systems (PAS)
    - Electronic practice management
    - Lab information systems (interfaces)
    - Dietary
    - Pharmacy (clinical decision support)
    - Billing
    - Electronic health records
- HL7 uses XML markup language
- The most current version of the HL7 standard is 3.0 but version 2.0 still widely in use
- The Clinical Document Architecture (CDA) is part of the HL7 standard and makes documents human readable and machine processable by using XML. CDA is used in electronic health records, discharge summaries and progress notes. CDA delineates the structure and semantics of clinical documents and consists of a header and a body.[60-61] In 2007 HL7 recommended (and HITSP endorsed) the use of the Continuity of Care Document (CCD) standard. The CCD is the marriage of the Continuity of Care Record (CCR) (developed by ASTM International) and the CDA (developed by the HL7 organization). It is the electronic document exchange standard for sharing patient *summary* information between physicians and within personal health records. It contains the most common information about patients in a summary XML format that can be shared by most computer applications and web browsers. In 2008 CCHIT required EHRs to generate and format CCD documents using the C32 specification for patient registration, medication history and allergies. This will represent one of the most important steps towards interoperable EHRs.[62-

[63] The CCD will have 17 data content/component modules as part of the C32 standards as noted in the table below. Each module will have additional data elements:

Table 4.3 Data modules of the C32 standard for the CCD
(R=required, R2 = required if available, O = optional)

Personal Information (R)	Condition (O)	Immunization (O)
Language Spoken (R2)	Medication (O)	Vital Sign (O)
Support (R2)	Pregnancy (O)	Result (O)
Healthcare Provider (O)	Information Source (R)	Encounter (O)
Insurance Provider (O)	Comment (O)	Procedure (O)
Allergy/Drug Sensitivity (O)	Advance Directive (O)	

Figure 4.6 HL7 example (The vertical bars are called pipes and separate the bits of data)

Digital Imaging and Communications in Medicine (DICOM)

- DICOM was formed by the National Electrical Manufacturers Association (NEMA) and the American College of Radiology. They first met in 1983 which suggests that early on they recognized the potential of digital x-rays
- As more radiological tests became available digitally, by different vendors, there was a need for a common data standard
- DICOM supports a networked environment using TCP/IP protocol (basic Internet protocol)
- DICOM is also applicable to an offline environment[64]

Institute of Electrical and Electronics Engineers (IEEE). IEEE is the organization responsible for writing standards for medical devices. This includes infusion pumps, heart monitors and similar devices. [65]

Logical Observations: Identifiers, names and codes (LOINC)

- This is a standard for the electronic exchange of lab results back to hospitals, clinics and payers. HL7 is the *messaging* standard, whereas LOINC is the *interpretation* standard
- The LOINC database has more than 30,000 codes used for lab results. This is necessary as multiple labs have multiple unique codes that would otherwise not be interoperable
- The lab results portion of LOINC includes chemistry, hematology, serology, microbiology and toxicology

- The clinical portion of LOINC includes vital signs, EKGs, echocardiograms, gastrointestinal endoscopy, hemodynamic data and others
- A LOINC code example is 2951-2 for serum sodium; there would be another code for urine sodium. The formal LOINC name for this test is: SODIUM:SCNC:PT:SER/PLAS:QN (component:property:timing:specimen:scale)
- LOINC is accepted widely in the US, to include federal agencies. Large commercial labs such as Quest and LabCorp have already mapped their internal codes to LOINC
- RELMA is a mapping assistant to assist mapping of local test codes to LOINC codes
- LOINC is maintained by the Regenstrief Institute at the Indiana School of Medicine. [66] LOINC and RELMA are available free of charge to download from www.regenstrief.org/loinc
- For more detail on LOINC we refer you to an article by McDonald [67]

EHR-Lab Interoperability and Connectivity Standards (ELINCS)

- ELINCS was created in 2005 as a lab interface for ambulatory EHRs and a further "constraint" or refinement of HL7
- Traditionally, lab results are mailed or faxed to a clinician's office and manually inputted into an EHR. ELINCS would permit standardized messaging between a laboratory and a clinician's ambulatory EHR
- Standard includes:
    - Standardized format and content for messages
    - Standardized model for exchanging messages
    - Standardized coding (LOINC)
- The Certification Commission for Healthcare Information Technology (CCHIT) has proposed that ELINCS be part of EHR certification
- HL7 plans to adopt and maintain the ELINCS standard
- California Healthcare Foundation sponsored this data standard[68]

RxNorm

- RxNorm is a new standard for drugs; developed by the National Library of Medicine
- The standard includes three drug elements: the active ingredient, the strength and the dose
- RxNorm is the standard for e-prescribing
- The standard only covers US drugs at this point [69]

National Council for Prescription Drug Programs (NCPDP)

- A standard for exchange of prescription related information
- The standard facilitates pharmacy related processes
- It is the standard for *billing* retail drug sales [70]

Systematized Nomenclature of Medicine: Clinical Terminology (SNOMED-CT)

- SNOMED is the clinical terminology commonly used in software applications including EHRs
- SNOMED is also known as the International Health Terminology
- This standard was developed by the American College of Pathologists. In 2007 ownership was transferred to the International Health Terminology Standards Development Organization www.ihtsdo.org
- SNOMED will be used by the FDA and the Department of Health and Human Services
- This standard currently includes about 1,000,000 clinical descriptions
- Terms are divided into 11 axes or categories
- The standard provides more detail by being able to state condition A is due to condition B
- SNOMED links to LOINC and ICD-9
- SNOMED is currently used in over 40 countries
- EHR vendors like Cerner and Epic are incorporating this standard into their products
- There is some confusion concerning the standards SNOMED and ICD-9; the latter used primarily for billing and the former for communication of clinical conditions [71-72]
- A study at the Mayo Clinic showed that SNOMED-CT was able to accurately describe 92% of the most common patient problems [73]

  SNOMED-CT Example: Tuberculosis

  D E – 1 4 8 0 0

  . . . .

  . . . .

  . . . Tuberculosis

  . . Bacterial infections

  . E = Infectious or parasitic diseases

  D = disease or diagnosis

International Classification of Diseases 9th revision (ICD-9)

- ICD-9 is published by the World Health Organization to allow mortality and morbidity data from different countries to be compared
- Although it is the standard used in billing for the past 30 years, it is not ideal for distinct clinical diseases
- ICD-10 was endorsed in 1994 but not used in the US. The Federal government initially set October 2011 as the launch date for ICD-10 but that has been changed to October 1 2013.[74] ICD-10 will provide a more detailed description with 7 rather than 5 digit codes. ICD-10 would result in about 200,000 codes instead of the 24,000 codes currently used. A study by Blue Cross/Blue Shield estimated that adoption of ICD-10 would cost the US healthcare industry about $14 billion over the next 2-3 years. The more digits included generally results in higher reimbursement [75-76]

Current Procedural Terminology (CPT)

- CPT is used for billing the level and complexity of service rendered
- Standard was developed, owned and operated by the American Medical Association (AMA) for a fee
- The 2003 version contains 8,107 billing codes [77]

Health Insurance Portability and Accountability Act (HIPAA): The Basics

HIPAA became a reality in 1996 but it has taken time to be implemented and evaluated. HIPAA is discussed in this chapter because it affects healthcare data transmission and storage. HIPPA was originally created to take care of the issue of portability of health information or what happens when a patient changes clinician or insurance company. It was not created to cover all issues with paper-based personal health information (PHI) so additional regulations had to be added to include coverage of electronic patient data. Importantly, HIPAA has added privacy and security standards for patient data exchange, similar to the data standards just discussed.

The public is very interested in the privacy and security of their personal data as evidenced by multiple surveys, including the 2005 National Consumer Health Privacy Study:

- 67% of Americans surveyed were concerned about personal health information privacy
- 52% were concerned about medical information affecting job opportunities
- 98% were willing to share health information with their physician, only 27% with drug companies and 20% with government agencies
- 66% thought paper records more secure than electronic! [78]

Further evidence of patient groups demonstrating interest in protection of personal health information was demonstrated by the HealthDataRights.org that published its Declaration of Health Data Rights in 2009 and was endorsed by several national initiatives such as Google Health. They maintain that patients:

- Have the right to their own health data
- Have the right to know the source of each health data element
- Have the right to take possession of a complete copy of their individual health data, without delay, at minimal or no cost; if data exist in computable form, they must be made available in that form
- Have the right to share their health data with others as they see fit [79]

We will be discussing only Title II (subtitle F) or *Administration Simplification* that is divided into four areas:

1. Standardization of electronic patient health, administrative and financial data
2. Privacy rules
3. Security standards protecting confidentiality and integrity of health information
4. Unique health identifiers for individuals, employers, health plans and clinicians

All healthcare organizations are subject to HIPAA and the following are considered "*covered entities*":

- Clinicians, nurses, dentists, hospitals, pharmacies, labs, nursing homes, etc
- Insurers (payers)
- Health care clearinghouses: systems that process health information like billing services

Privacy Rules

- The goal is to define and protect individually identifiable personal health information (PHI) that includes name, address, phone number, SSN, health care specifics and payment information. In reality there are nineteen patient identifiers that must be removed or de-identified in order to no longer be considered PHI[80]
- ePHI is PHI in an electronic format
- HIPAA covers all PHI regardless whether it is electronic, oral or written
- Clinicians do not need to obtain patient permission to use health information for treatment or payment or business operations. There has been confusion regarding this, particularly in an emergency situation[81]
- Patients sign an authorization to release PHI *unless* the information deals with infectious outbreaks, statistics related to patient safety, criminal matters or deceased patient issues
- HIPAA requirements include:
    - Internal protection of medical records
    - A written statement of privacy practices to patients
    - Employee privacy training
    - Privacy complaints must be addressed
    - Designation of a privacy officer
    - De-identifiable patient information, when possible
- The Joint Commission and Medicare inspections will likely look at HIPAA compliance

Security Standards

- There are 18 security standards. Implementation specifications are either required or addressable. If addressable, the practice must document why it cannot be implemented, otherwise it is required
- Standards are divided into: administrative, physical and technical:
    - **Administrative**: policies and procedures that implement security measures to protect health information and manage the conduct of employees
    - **Physical**: policies and procedures that protect practice health information from natural disasters and intrusion. Example, locking charts up at the end of the day
    - **Technical**: policies and procedures that control access to protected health information such as secure log-ons and authentication[82]

Unique Identifiers

- HIPAA requires the use of a unique identifier for clinicians, health plans, employers and patients

- The National Committee on Vital and Health Statistics will advise the Secretary of HHS regarding identifiers
- The National Provider System issued a 10 digit numeric identifier or National Provider Identifier to clinicians. It will replace, the UPIN and insurance provider IDs. The deadline for compliance was May 2007
- The National Employer Identifier will use the employer identification number (EIN)
- As of 2009, the National Health Plan Identifier for payers is on hold
- As of 2009, the National Patient Identifier is on hold due to privacy concerns[83]

Effect of Stimulus Package on HIPAA

The new language was intended primarily to fix the holes in health information exchanges, PHRs, etc that existed with the original HIPAA legislation. The modifications are as follows but details have not been fully worked out.

- Defines breach to include all "unauthorized acquisition, access, use or disclosure of protected health information
- Individuals will have to be notified within 2 months of any security breach or unauthorized use of unencrypted PHI
- Vendors related to HIOs, PHRs and E-prescribing are now considered business associates and subject to the same standards as "covered entities"
- A covered entity must account for all disclosures of PHI for 3 years
- State and local authorities gain HIPAA enforcement authority
- Patients have the right to access some of their data in electronic format and accounting for any disclosure of PHI
- Restricts the sale and marketing of PHI by requiring patient consent[84]

Benefits of HIPAA

- Patients can ask to see, copy and amend their medical records, unless they are mental health records
- Patient can request restrictions to access to their records
- Patients can request an audit of who has accessed their record for the past six years
- States can opt for more stringent privacy than HIPAA, but not less

Limitations of HIPAA

- No consent needed for information sent to insurance companies
- Sensitive past medical information could become public
- Health information can be released to businesses looking to recall or replace drugs or devices
- Patients cannot sue for breach of privacy under HIPAA

- Law enforcement may have limited access to protected health information (PHI) without consent, as do public health officials and those working with the deceased
- HIPAA violations are infrequent but gain national attention
    - In 2008 Providence Health paid $100,000 for unprotected back-up tapes, optical disks and laptop computers[85]
    - In 2009 CVS pharmacy agreed to pay a $2.25 million in fines following an investigation into violations of the HIPAA Privacy rule. It was alleged that CVS failed to implement adequate policies and procedures to secure protected information[86]
- Will malpractice insurance cover a HIPAA violation?
- Will HIPAA slow down necessary innovation and modernization?
    - In 2007 the Institute of Medicine (IOM) sponsored the Committee on Health Research that concluded that HIPAA Privacy Rule doesn't adequately protect PHI, yet it impedes health research
    - IOM recommendations are available in a monograph[87]
- Those not covered by HIPAA:
    - Life insurance companies
    - Workers' compensation
    - Internet self help sites
    - Law enforcement agencies
    - Researchers who get information from primary care managers
    - Healthcare screening
    - Agencies that deliver social security and welfare benefits[88-89]

Key Points

- Lack of interoperability is one of the greatest challenges facing health information exchange
- In order to create a Nationwide Health Information Network (NHIN) multiple data standards will need to be reconciled and adopted
- Creating the architecture for a Health Information Organization (HIO) is not difficult; developing the long term business plan is
- We are slowly moving towards industry wide standards such as the Continuity of Care Document (CCD)
- Important interoperable demonstrations of the NHIN have taken place
- The NHIN will now have multiple participating civilian and federal partners
- Data privacy and security are critical issues for health information exchange

Conclusion

Interoperability makes the HIT world go around. Without it, technology would not work the same in each state. Data standards are mandatory for the exchange of health information, but they still are a work-in-progress. HIOs will also be impeded by an almost universal lack of a business model for sustainment, as well as privacy and security issues. The federal government is moving forward with the Nationwide Health Information Network in an effort to accelerate standards creation and adoption, in spite of the many problems with creating HIOs across the nation and the low adoption rate of EHRs. In the meantime, insurance companies will create new electronic clinical record models based on claims data. It is too early to know what a HIO will look like in the next decade. HIPAA adds necessary privacy and security standards but also creates new hurdles to overcome.

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5

Networks

ROBERT E HOYT

Learning Objectives
After reading this chapter the reader should be able to:

- Understand the importance of networks in the field of medicine
- Compare and contrast wired and wireless LANs
- Describe the newest wireless broadband networks and their significance

A network is a group of computers that are linked together in order to share information. Although a majority of medical data resides in silos, there is a distinct need to share data between offices, hospitals, insurers, health information organizations, etc. A network can share patient information as well as provide Internet access for multiple users. Networks can be small, connecting just several computers in a clinician's office or very large, connecting computers in an entire organization.

There are several ways to access the Internet: dial-up modem, WiFi, satellite and broadband access using a Digital Subscription Line (DSL), cable modem or T1 lines. The most common type of DSL is Asymmetric DSL (ADSL) which means that the upload speed is slower than the download speeds, because residential users utilize the download function more than the upload function. Symmetric DSL is also available and features similar upload and download speeds. Cable modem often begins with fiber optic transmission to the building, with coaxial cable run internally. The following are network data transfer speeds based on the different technologies. Multiple factors influence these speeds, so that theoretical maximum as well as more typical speed ranges are listed.

Table 5.1. Data transfer rates

Transmission method	Theoretical max speed	Typical speed range
Dial-up modem	56 Kbps	56 Kbps
DSL	6 Mbps	1.5 Mbps download/128 Kbps upload
Cable modem	30 Mbps	1-6 Mbps download/128-768 Kbps upload
Wired Ethernet (Cat 5)	1000 Mbps	100 Mbps
Fiber optic cable	100 Gbps	2.5-40 Gbps
T-1 line	1.5 Mbps	1-1.5 Mbps
Wireless 802.11g Wireless 802.11n	54 Mbps 300 Mbps	1-20 Mbps 40-115 Mbps
WiMax	70 Mbps	54-70 Mbps
LTE	60 Mbps	8-12 Mbps
Bluetooth	24 Mbps	1-24 Mbps

Information Transmission via the Internet

Given the omnipresent nature of the Internet and broadband speeds, the Internet is the network of choice for transmission of voice, data and images. It is important to understand the basics of transmission using packets of information. The Internet Protocol (IP) is a standard that segments data, voice and video into packets with unique destination addresses. Routers read the address of the

packet and forward it towards its destination. Transmission performance is affected by the following:

- Bandwidth: is the size of the pipe to transmit packets. In reality, networks should have bandwidth excess to operate optimally
- Packet loss: packets may rarely fail to reach their destination. The IP Transmission Control Protocol (TCP) makes sure a packet reaches its destination or re-sends it. The User Datagram Protocol (UDP) does not guarantee delivery and is used with, for example, live streaming video. In this case the user would not want the transmission held up for one packet
- End-to-end delay: is the latency or delay in receiving a packet. With fiber optics the latency is minimal because the transmission occurs at the speed of light
- Jitter: is the random variation in packet delay and reflects Internet spikes in activity

Security and Privacy: packets travel through the very public Internet. An encryption technique such as the Federal Information Processing Standard (FIPS) encodes the content of each packet so that it can't be read while being transmitted on the Internet. Encryption, however, adds some delay and increase in bandwidth requirements[1]

Network Types

Networks are named based on connection method, as well as configuration or size. As an example, a network can be connected by fiber optic cable, Ethernet or wireless. Networks can also be described by different configurations or topologies. They can be connected to a common backbone or bus, in a star configuration using a central hub or a ring configuration.[2-5] In this chapter we will describe networks by size or scale.

Personal Area Networks (PANs): Bluetooth technology has been around since 1995 and is designed to connect an assortment of devices at a maximum distance of about 30 feet. It does have the advantages of not requiring much power and connecting automatically, but has the disadvantage of being slower, with speeds of 1 Mbps. It operates in the 2.4 MHz frequency range so it can interfere with 802.11g networks. Clearly, the most common application of Bluetooth today is as a wireless headset to connect to a mobile phone. Many new computers are Bluetooth enabled and if not, a Bluetooth USB adapter known as a dongle can be used or a Bluetooth wireless card. This technology can connect multiple devices simultaneously and does not require "line of sight" to connect. In an office Bluetooth can be used to wirelessly connect computers to keyboards, mice, printers, PDAs and smartphones. This will avoid the tangle of multiple wires. Bluetooth can connect in one direction (half duplex) or in two directions (full duplex). Security must be enabled due to the fact that even though the transmission range is short, hackers have taken advantage of this common frequency. In the near future it is anticipated that low energy Bluetooth devices such as heart monitors will be available with very long battery lives. In addition, faster Bluetooth 3.0 devices will be available in the 2009-2010 timeframe with speeds in the 24 Mbps range that piggyback on the 802.11 standard.[2]

Local Area Networks (LANs): Generally refers to linked computers in an office, hospital, home or close proximity situation. A typical network consists of nodes (computers, printers, etc), a connecting technology (wired or wireless) and specialized equipment such as routers and switches. LANs can be wired or wireless:

- **Wired networks**: To connect to the Internet through your Internet Service Provider (ISP) you have several options. **Modem:** you can use the older and slower modem technology to connect your computer to the Internet over routine phone lines. **Ethernet** is a network protocol and most networks are connected by fiber or twisted-pair/copper wire connections. Ethernet networks are faster, less expensive and more secure than wireless networks. The most common Ethernet cable is category 5 (Cat 5) unshielded twisted pair (UTP). To connect several computers in a home or office scenario you will need a hub, although they have largely been replaced by network switches. You will also need a network card but most recently manufactured computers already have this installed. Routers direct messages between networks and the Internet; whereas, switches connect computers to one another and prevent delay. Unlike Hubs that share bandwidth, switches operate at full bandwidth. Switches are like traffic cops that direct simultaneous messages in the right direction. They are generally not necessary unless you are running multiple computers on the same network. To handle larger enterprise demands Gigabit Ethernet LANs are available that are based on copper or fiber optics. Cat5e or Cat6 cables are necessary. Greater bandwidth is necessary for many hospital systems that now have multiple IT systems, an electronic medical record and picture archiving and communication systems (PACS). A typical wired LAN is demonstrated in Figure 5.1.[2-5]

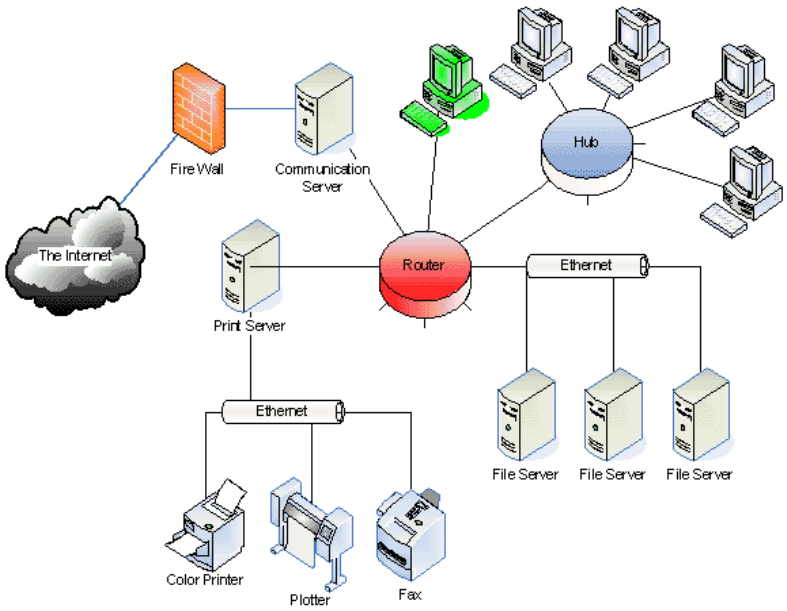

Figure 5.1 Typical wired local area network (Courtesy Dept of Transportation)

Other options to connect computers include phone lines and power lines. Phone lines can be used to bring the signal into the office or home and can be used to create a network. Digital subscription lines (DSL) uses standard phone lines that have additional capacity (bandwidth) and are much faster network connection than modems. DSL also has the advantage over modems of being able to access the Internet and use the telephone at the same time. Home or office networks can use phone lines to connect computers, etc. Newer technologies include frequency-division multiplexing (FDM) to separate data from voice signals. This type of network is inexpensive and easy to install. Speeds of 128 Mbps can be expected even when the phone is in use. Up to 50 computers can be connected in this manner and hubs and routers are not necessary. Each computer must have a home phone

line network alliance (PNA) card and noise filters are occasionally necessary. The downside is largely the fact that not all home rooms or exam rooms have phone jacks. Power lines are another option using standard power outlets to create a network. A newer product (PowerPacket) is inexpensive to install and claims data transfer speeds of 14 Mbps. All that is needed is a power outlet in each room.[4]

- **Wireless (WiFi) networks (WLANs):** Wireless networks are based on the Institute of Electrical and Electronics Engineers (IEEE) 802.11 standard and operate in the 900 MHz, 2.4 GHz and 5 GHz frequencies. These frequencies are "unlicensed" by the FCC and are therefore available to the public. Figure 5.2 shows the radio frequency portion of the electromagnetic spectrum where wireless networks function.

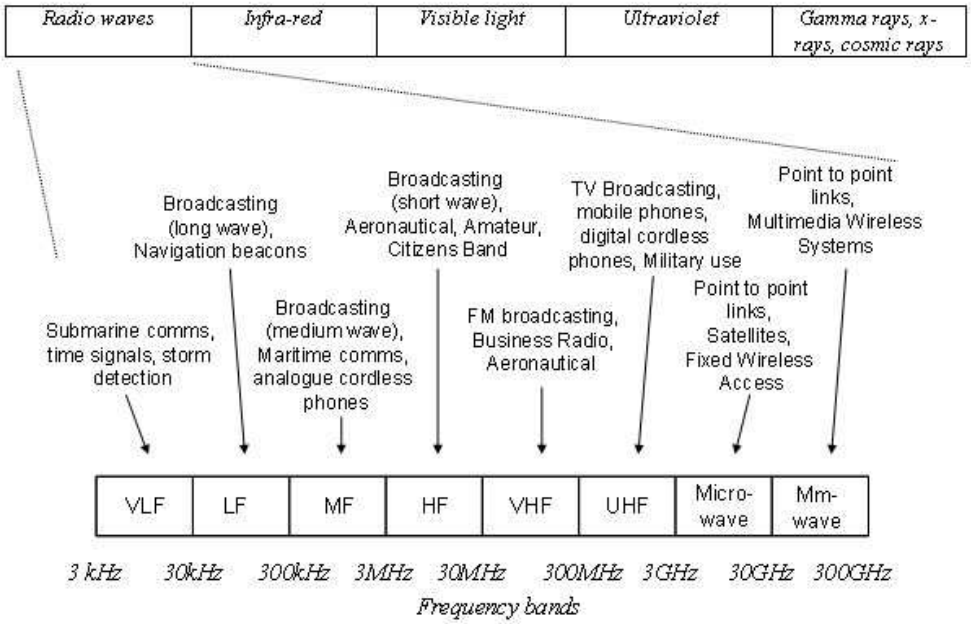

Figure 5.2 Radio frequency spectrums (Courtesy Commission for Communications Regulation)

Wireless networks have become much cheaper and easier to install so many offices and hospitals have opted to go wireless to allow laptop/tablet PCs and smartphones in exam and patient rooms. It also means that it is unnecessary to hardwire the network but it does mean that a wireless router or access points are needed. If an office already has a wired Ethernet network then a wireless access point needs to be added to the network router. The mode that utilizes a wireless router or access point is known as the infrastructure mode. The other mode is known as ad hoc or peer-to-peer mode and means that a computer connects wirelessly to another computer and not to a router.

In general, wireless is slower than cable and is more expensive, but does not require hubs or switches. The standards for wireless continue to evolve. Most people have used 802.11g networks that operate on the 2.4 GHz frequency at peak speeds of 54 Mbps with a range of about 100 meters. Keep in mind that this frequency is vulnerable to interference from microwaves, some cordless phones and Bluetooth. 802.11n is the newest standard that can operate at speeds up to 300 Mbps with a range of about 300 meters. This is accomplished with multiple input/multiple output (MIMO) or multiple antennas that send and receive data much faster and at greater distances. Actual data transfer speeds may be slower than the theoretical max speeds for several reasons. Most modern laptop computers

have wireless technology factory installed so a wireless card is no longer necessary. In Figure 5.3 a simple WLAN is demonstrated. Access to the Internet is via a cable modem with the possibility of both Ethernet and wireless connectivity to different client computers demonstrated. A wireless router will connect the computers, server and printers and has a range of about 90-120 feet. For a larger office or hospital multiple access points will be necessary. The network router is usually connected to the Internet by an Ethernet cable to DSL or a cable modem. Security must be established by using wired equivalent privacy (WEP) 128-bit encryption, a router firewall and a unique media access control (MAC) addressee. Each device has a unique address (MAC) and routers can have security lists that only allow known devices or MACSs into the network.[6-8]

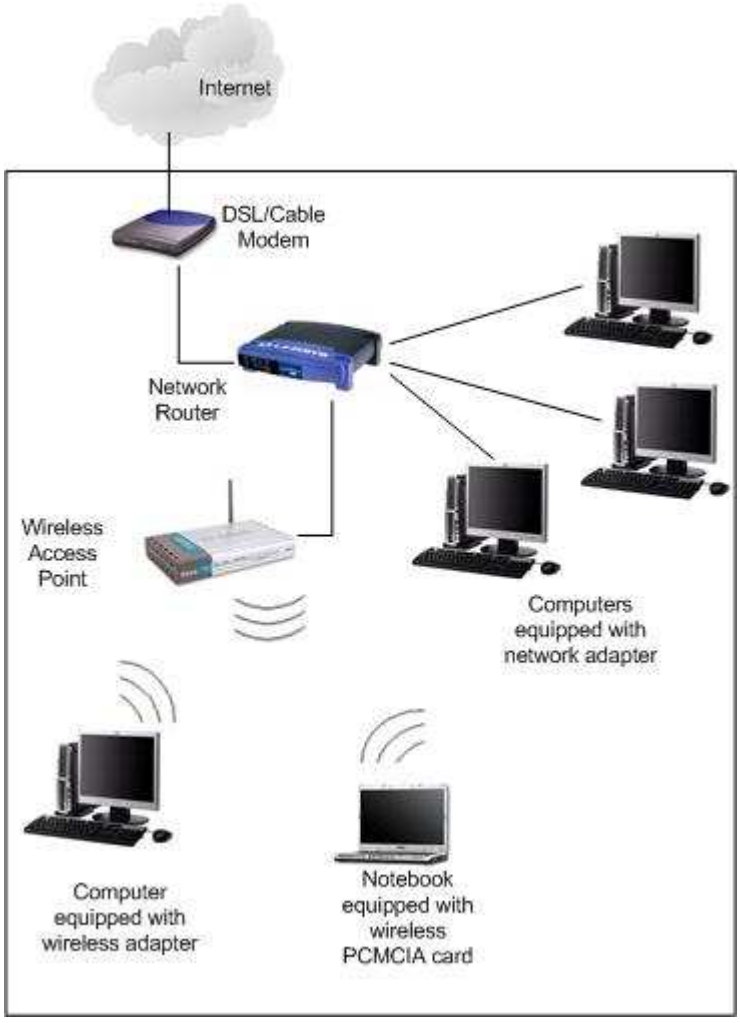

Figure 5.3 Wireless Local Area Network (WLAN) (Courtesy Home-Network-Help.com)

An emerging trend for hospitals is to use Voice over IP on a wireless network, referred to as VoWLAN. Hospitals can use existing wireless networks to contact nurses, physicians and employees with any wireless enabled device. Devices such as the Nortel VoWLAN phone or Vocera are frequently used. The chief advantage of this approach is saving local and long distance phone call charges. Using this technology, a patient could directly contact a nurse making rounds so a nurse is not forced to be located near a central nurse-call system. While in the hospital this system could replace landlines, pagers, cell phones and 2-way radio. The downside is that a strong signal is necessary for this system and is more important than that needed with just data.[2]

Another wireless option is wireless mesh networks that rely on a single transmitter to connect to the Internet. Additional transmitters transmit signals to each other over a wide area and only require a power source. Municipalities, airports, etc are using this type of technology to cover larger defined areas.[4]

Wide Area Networks (WANs): Cross city, state or national borders. The Internet could be considered a WAN and is often used to connect LANs together.[4]

Global Area Networks (GANs): The problem with broadband technology is that it is expensive and the problem with WiFi is that it may result in spotty coverage. These shortcomings have created a new initiative known as Worldwide Interoperability for Microwave Access (WiMax), using the IEEE 802.16 standard. The network will be known as a global area network (GAN) with operating speeds in the 54-70 Mbps range. The goal is to be faster than standard WiFi and reach greater distances, such that it might replace broadband services and permit widespread wireless access to the Internet. A user would be able to access the Internet while traveling or from a fixed location. It would require WiMax towers, similar to cell towers, and a WiMax card in computers, similar to wireless cards. A tower could conceivably cover 3,000 square miles. This would permit a user to connect "non-line of sight" with a weaker lower frequency antenna or line of sight with a higher frequency and stronger dish antennae. WiMax technology also permits voice over IP (VoIP) or phone calls over the Internet. WiMax may replace several 3 G networks and could be considered a 4 G strategy or "broadband wireless". A WiMax network is illustrated in Figure 5.4. In 2008 several companies including Sprint, Intel, Comcast, Cisco and Google collaborated to develop a new company known as Clearwire to promote and develop WiMax technology. This company plans to cover 120 million Americans by 2010 and is currently being offered in Atlanta, Ga.[2, 9]

The second 4 G wireless network being rolled out in four US cities is known as Long Term Evolution or LTE. Verizon plans to start widespread implementation in 2010 with completion in about 5 years. Operating in the 700 MHz range it is touted to have maximum speeds of 60 Mbps with realistic speeds of 8-12 Mbps. It is unknown how expensive WiMax or LTE will be.[10]

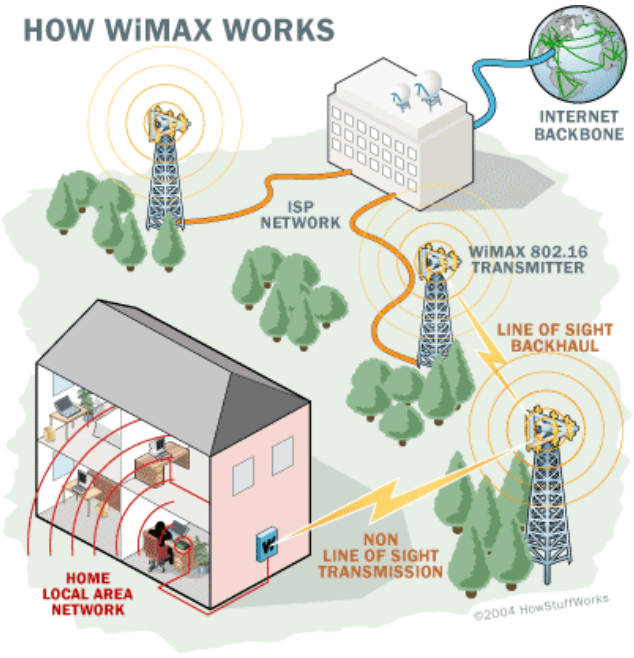

Figure 5.4 WiMax networks (Courtesy How Stuff Works)

Virtual Private Networks (VPNs): If a clinician desires access from home to his/her electronic health record, one option is a VPN. In this case your home computer is the client and the computer at work you are trying to access is the VPN server. The Internet is the means of connection and VPN will work with wired or wireless LANs. Authentication and overall security are key elements of setting up remote access to someone else's computer network. (Figure 5.5) "Tunneling protocols" encrypt data by the sender and decrypt it at the receiver's end via a secure tunnel. In addition, the sender's and receiver's network addresses can be encrypted.[2, 5]

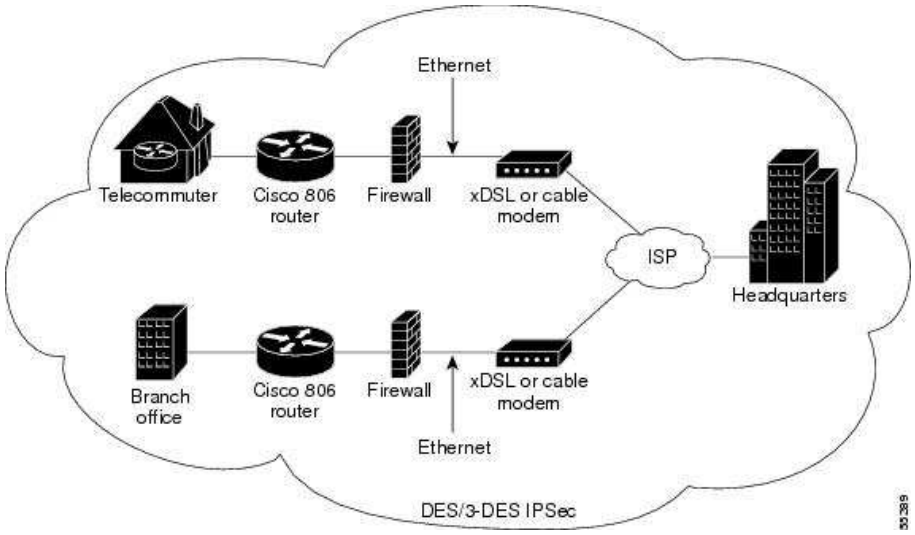

Figure 5.5 Virtual private network diagram (Courtesy Cisco)

Key Points

- Clinicians who use client-server based electronic health records need to establish a wired or wireless office network
- Wireless networks have become more attractive due to faster speeds and lower prices
- Wireless broadband is around the corner and will make Internet access faster and more widely available

Conclusion

Hospitals' and clinicians' offices rely on a variety of networks to connect hardware, share data/images and access the Internet. In spite of initial cost, most elements of the various networks discussed continue to improve in terms of speed and cost. Many clinician offices will require a network expert to ensure proper installation and maintenance. Wireless technology (WiFi) has become commonplace in many medical offices and hospitals. When wireless broadband (WiMax-LTE) becomes cost effective and widely available it may become the network mode of choice. Network security will continue to be an important issue regardless of mode.

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6

Patient Informatics

ROBERT E HOYT

Learning Objectives

After reading this chapter the reader should be able to:

- Identify the origin of patient informatics and the role of the Internet in patient education
- List the standard features of a patient web portal
- Compare and contrast the various types of personal health records and their projected benefits
- Describe the evolving role of secure e-mail and virtual visits as a new form of patient-physician communication and interaction

Patient Informatics (also known as consumer informatics) is a new aspect of Medical Informatics that largely reflects the empowered healthcare consumer. Patients are aware that many non-healthcare businesses are automating and modernizing their business processes to attract a larger market share. ATM machines, as an example, can provide cash in a few minutes regardless where you are located worldwide. This innovation required re-engineering and the acceptance of universal standards, not unlike many aspects of health information technology.

You do not have to look very far to find evidence of new patient-oriented healthcare:

- Walmart and other retailers are offering convenient walk-in clinics in their stores[1]
- Healthcare blogging through sites like Trusted.MD are becoming popular for patients.[2] There are also health blogs for physicians known as Sermo (Latin for conversation),[3] iMedexchange[4] and Medscape Physician Connect[5]
- An emergency room in Dallas, Texas has a self-service electronic check-in kiosk to expedite medical care[6]
- Dental practices can text message patients on their cell phones to remind them of upcoming appointments[7]

All of these recent forms of patient informatics have occurred in just the past five to ten years. Unfortunately, little has been written in the medical literature about this topic so we must rely primarily on surveys and expert opinions. In table 6.1 results of a 2006 Harris Interactive survey of 2,624 adults show the informatics features desired by respondents and the percentages. Note that most of their desires are easily achievable technologically but unavailable in many healthcare systems.[8]

In this chapter we will discuss the following four topics in patient informatics. It should become obvious after reading the chapter that these four areas are interwoven and not truly separate. In addition, many of these features can be found associated with electronic health records and health information organizations.

1. The Internet for patient medical education
2. Web portals for patient access to their healthcare system
3. Personal health records

4. Patient-physician communication via secure e-mail and e-visits

Table 6.1 Consumer desires and percentages

Desired informatics features by respondents	% Users
E-mail reminder of upcoming appointments	77%
Schedule medical appointments online	75%
Communicate with physician via e-mail	74%
Receive test results via e-mail	67%
Access to their electronic health record	64%
Home monitoring that would transmit information to physician's office	57%

The Internet for Patient Medical Education

Multiple surveys have confirmed that the Internet is the premier medical resource for both patients and medical professionals. This has occurred in the incredibly short time span of just 10-15 years. According to a 2005 survey by the Pew Internet & American Life Project, 87% of respondents aged 29-40 used the Internet (at least once), compared to only 21% aged 70 or older. In those who used the Internet, all age groups searched for health information. Furthermore, approximately 63% of adults have broadband access at home or at work. The individuals most likely to seek health related information online are women, age younger than 65, college graduates, those with more online experience and those with broadband access.[9] A 2008 Pew Internet & American Life Project survey of California adults reported that 80% searched the Internet for health related issues, but the search usually did not change their care.[10] It should be pointed out that this is United States data as many countries are more "wired" than the US and many more are less connected.[11] Additionally, there is a significant digital divide between ethnic and racial groups in the United States. In a 2003 study by the National Center for Education Statistics, 54% of white students used the Internet at home as compared to about half that for Hispanic and African-American youth.[12]

In another survey by Opinion Research Corporation it was noted that the top healthcare worries prompting Internet searches were: cost (41%), quality (25%), medical errors (16%) and all others (18%).[13] Table 6.2 shows the types of medical topics searched on the Internet. Although specific diseases were most commonly researched it was noteworthy that insurance issues, hospitals and doctors were also commonly researched.[9]

Table 6.2 Health topics searched

Topics Searched	% Users who searched
Specific Disease	63
Medical Treatment	47
Diet and Nutrition	44
Exercise	36
Medication Issues	34
Alternative Medications	28
Insurance Companies	25
Depression	21
Doctor or Hospital	21

Recent events confirm that patients are becoming more discriminating in their choices of all aspects of healthcare. No longer do they automatically accept the opinion of their physicians. In a Harris poll it was shown that 57% of patients discussed their Internet search with their physician and 52% searched the Internet after talking to their physician. Eighty nine percent felt their search was successful demonstrating confidence in the Internet as the new health library.[14] Excellent medical web sites exist but searches may yield low quality, non-evidence based answers, particularly when personal web sites are searched. As an example, in one study of Internet searching for the treatment of childhood diarrhea, 20% of searches failed to match the guidelines published by the American Academy of Pediatrics.[15]

Multiple reasons have been suggested for the increased use of the Internet in the healthcare arena:

- Healthcare is becoming more patient-centered in general. This has been promoted by the Institute of Medicine in all of their publications[16]
- Quality patient education web sites abound
- Most non-medical businesses are offering an online method to promote services, pay bills, etc
- The increasing use of medical blogs, podcasts and wikis as part of the Web 2.0 movement (the use of the Internet for free collaborative purposes) is very popular with patients[17]
- Patients are becoming impatient about finding the right answers, the best physicians, the best hospitals and the best medical care at the lowest cost
- Our population is "*graying*" with an estimated 78 million Baby Boomers who are well educated and have more disposable income. This results in higher expectations. There is some evidence that patients expect their physicians to be tech savvy and would consider switching if they are not
- Healthcare organizations are using information technology as a marketing tool to attract patients
- Computers are ubiquitous, as are broadband connections. Searching the Internet is now very fast and easy
- Patients receive less face time with their physicians causing some patients to turn to the Internet for answers

Examples of Online Patient Education Web Sites

The following are only a sample of the many valuable patient education web sites available today.

WebMD. With more than 30 million people visiting this site monthly, it should be considered one of the true standard bearers. They have an extensive health library with top topics listed for men, women and children. Treatment and drug information is available, as is medical news. A symptom checker tool provides a patient with a simple differential diagnosis of what might be wrong with them based on their symptoms, age and gender. A daily e-mail newsletter is offered that can be customized to a patient's concerns. The only negative about this site is limited commercial influence.[18]

Revolution Health. This site was launched in 2007 and backed by America Online as well as personalities such as Colin Powell and Carly Fiorina. Personal health records are an option, as are disease information, forums, CarePages, health calculators, a physician finder and symptom

checker. Members can rate physicians and hospitals, in addition to treatments and medications. They also offer an insurance marketplace to discuss and compare insurance options. Although these services are free, they also offer a fee-based membership that will allow a member to call and discuss a health concern 24 hours a day. There is limited commercial influence in the form of ads. [19]

MedlinePlus. This is the premier free patient education site developed by the National Library of Medicine and the National Institute of Health that links to the best and most respected web sites, such as the Mayo Clinic. MedlinePlus was ranked as the top information/news web site on the American Customer Satisfaction Index of federal government web sites.[20] In spite of its high marks, many patients and clinicians do not know about this site and many healthcare organizations pay for patient education content that could be obtained for free. Features of the web site include:

- 700+ health topics
- Drug information
- Health encyclopedia
- 165 tutorials
- Videos of surgical procedures
- Topics available in 40 languages
- Health check tools: quizzes, calculators and self-assessments
- Health dictionary
- Directories to locate physicians and hospitals
- Clinical Trials.gov to determine where experimental and new treatments are being studied in the USA
- Other health databases
- Health news

Figure 6.1 shows the results of a search for obesity, showing the high quality references and the convenient folders on the left.[21]

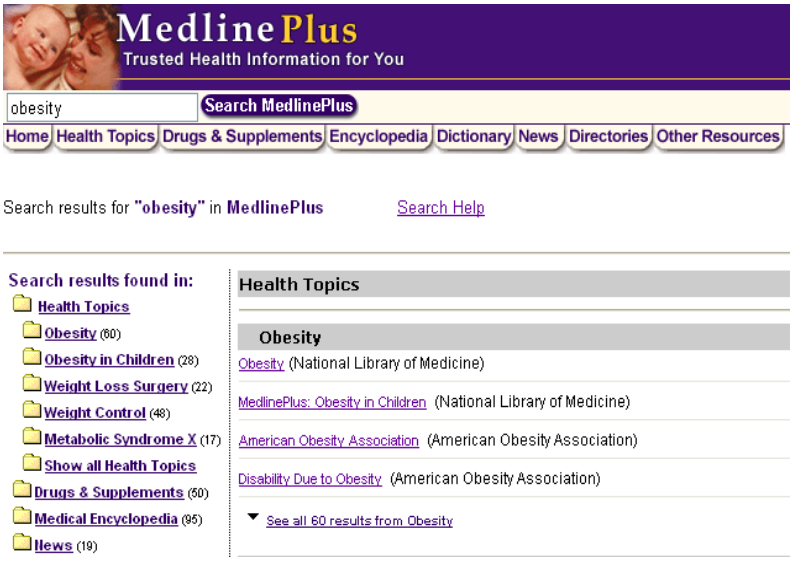

Figure 6.1 Search results for obesity (courtesy MedlinePlus)

Healthfinder. This web site was developed by the National Health Information Center and the Department of Health and Human Services and is very similar to MedlinePlus. It provides general information for the average patient.[22]

Florida State University Medical Library. Developed by Nancy Clark, this site includes MedlinePlus, Healthfinder and twenty two other general patient education web sites. Importantly, it links to twelve Pediatric and fourteen specialty resources. It would likely cover any subject experienced by the average patient.[23]

Healthwise. Multiple companies sell patient education for use on commercial medical web sites. Healthwise is a not-for-profit company that provides more than 6,000 medical topics in their knowledgebase. Other features include decision making tools, "take action tools" for chronic diseases and over 1,000 illustrations.[24]

UpToDate. This extremely popular physician education site also has a patient education site, aimed at college educated patients, unlike many sites that are aimed at high school educated patients. There is no charge for limited access to this site that covers more than 20 medical categories. For access to all articles posted, there is a charge. [25]

FamilyDoctor. The American Academy of Family Physicians sponsors this comprehensive free site. They cover all age groups as well as over the counter (OTC) drugs and a large library of health videos.[26]

Lab tests online. This free site allows for searching by test, disease condition or screening. The site is well organized with excellent resources for those seeking more information about clinical tests, why they are drawn, the results and what abnormal results mean. [27]

Patient Web Portals

Web portals are web-based programs that patients can access for health related services. A web portal can be a standalone program or it can be integrated with an electronic health record. Patient portals began as a web based entrance to a healthcare system for the purpose of learning about a hospital, healthcare system or physician's practice. Also, they were clearly a marketing ploy to attract patients who were Internet savvy. Currently, patient portals offer multiple patient services (Table 6.3).

Table 6.3 Web portal features and comments

Feature	Comments
Online registration	Allows patients to complete information before a visit or hospitalization
Medication refills	Secure message can be left for physician to refill or renew medications, instead of telephone calls
Laboratory results	Patients can find results on recent tests as well as an explanation
Electronic visits	Portals exist that facilitate e-visits and the payment process
Patient education	Links to common educational sites
Personal health records (PHRs)	Allows patients and their families to create and update their PHR
Online appointments	Allows patients to see what appointments are available and when
Referrals	Patients can request referrals to specialists, e.g. OB-GYN
Secure messaging	More convenient than playing phone tag
Bill paying	Online payment using credit card is faster than snail mail
Document uploading	Several portals allow uploading of medical records to their site
Tracking function	Portal allows patients to upload diet, blood sugars, blood pressures, etc

Most patient portals offer multiple services, whereas others like TeleVox offer a specific service like lab results notification. This secure web based program, known as LabCalls™ enables patients to access a web site and obtain lab results. The nurse or doctor leaves the results along with a canned explanatory message. Patients can also receive a text message on their cell phone that lab results are ready. This program integrates with the practice management system or the EHR.[28]

As you can see from figure 6.2 patients now have other ways to communicate with their physician besides face-to-face. Time will tell how well these new forms of e-communication work, how cost effective they are, how well they are reimbursed and how well they are liked by physicians and patients.

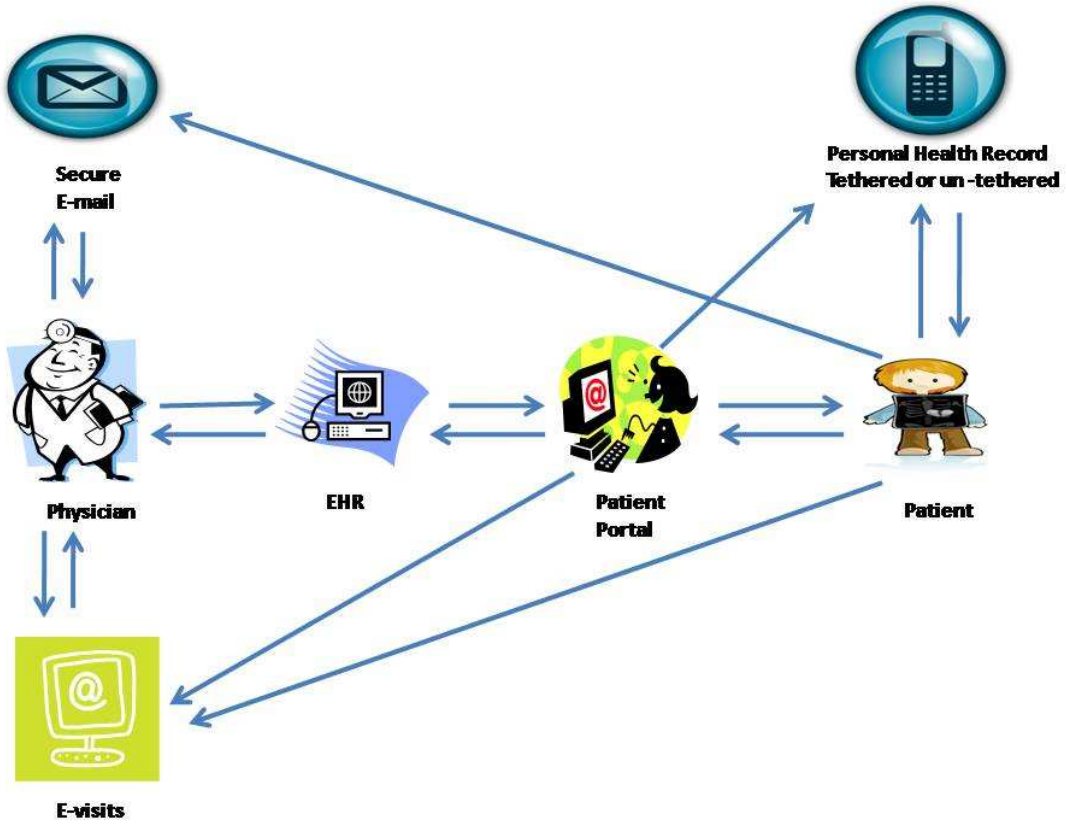

Figure 6.2 Patient, physician and chart interactions

A minority of web portals actually integrate with an EHR, which means that most patient data has to be manually inputted. In the future when EHRs become more widespread, selected patient lab results will automatically upload to the patient portal, thus saving time and money. Patients will also be able to access parts of their electronic records. A 2006 Harris Interactive study showed that 83% of patients wanted lab tests online and 69% wanted online charts to manage chronic conditions.[29] Although several studies have shown interest in having access to lab results it remains to be seen if that would change consumer behavior or clinical outcomes. Are these patients primarily college educated and tech savvy? Do they desire results because physicians' offices are too slow to provide results? In a study at Beth Israel hospital, patients who accessed their portal PatientSite were younger and with fewer medical problems. They tended to access lab and x-ray results and use secure messaging more than a non-enrollee group.[30] In another survey by Connecting for Health, patients were asked "*I think that having my health information online would*" with the following responses:

- 71% said it would clarify doctor instructions
- 65% said it would prevent medical mistakes
- 60% said it would change the way patients managed their health
- 54% said it would improve the quality of care [31]

Little is written about the benefits of patient web portals for the general consumer. McLeod Health System in Florence, South Carolina used online scheduling as part of the portal NexSched and was able to demonstrate fewer "*no shows*" and claims denials. They predicted a savings of about $1 million dollars yearly as a result of this program.[32]

Group Health Cooperative, a large mixed-model healthcare organization studied the effect of integrating its new comprehensive patient portal MyGroupHealth with its Epic electronic health record. As of December 2005, the highest monthly user-rates per 1,000 adult members were: test results, med refills, after-visit summaries and patient-provider messaging. A patient satisfaction survey revealed that the satisfaction rates were: 94% were satisfied overall, 96% for med refills, 93% for patient-provider messaging and 86% for test results. Although early use of the web portal was low there was a steady increase over time. Attrition rates were not reported.[33-34]

Robert Wood Johnson Foundation has awarded $2.45 million dollars to six organizations to study the effect of patient portals on chronic disease.[35]

Examples of Patient Web Portals

MySaintAls. This is the portal for Saint Alphonsus Medical Center located in Boise, Idaho. This comprehensive portal offers all of the standard features as well as the unique Patient Vault. They charge $10 monthly to upload (scan) and store patient records on their server. Lab results are accompanied by a separate program that explains the significance of the results and likely reduces the number of routine questions.[36]

Epic MyChart is a patient portal integrated with a well established electronic health record system. As of September 2007, over 26,000 patients logged in monthly to MyChart at the Palo Alto Medical Foundation. This portal enables access to diagnoses, medications, allergies, needed preventative tests, test results, x-ray results and appointments. An interactive demo is available on the web site.[37-39]

RelayHealth. This portal has traditionally been a standalone product but in 2006 they offered integration with several EHRs. In 2006 they were acquired by McKesson Corporation. They have been very successful in getting insurance companies such as Aetna, Cigna and Blue Cross/BlueShield to utilize their platform. Their business model is to charge physicians a monthly fee to cover e-visits using their secure messaging site. They offer the following standard features:

- E-visits are part of the portal and the vendor handles eligibility, claims and collections
- They offer 100 interactive structured interviews to keep the e-visit focused and fact based
- Personal health records
- Access to lab results
- E-prescribing and refills
- Online appointments
- Pre-registration
- Phone message routing
- Ability to create a practice web site
- Colleague to colleague secure messaging

- Interoperability tool kit to link to EHRs (McKesson, GE Centricity, NextGen, Epic, Cerner, AllScripts Touchworks, A4 HealthMatics and Practice Partner)
- Electronic data exchange (Results Distribution Service) to transmit lab, x-ray, discharge summaries, etc to physician offices or to the EHR. Results can then be forwarded to patients or other clinicians
- The ability to store portal information on Microsoft's HealthVault
- Active notification of pending results is available[40]

MedFusion is a portal that offers many of the same features as RelayHealth with the additional unique feature of online bill payment. They also have an extensive knowledge library of 6000 medical conditions to expedite an e-visit. A free return on investment (ROI) calculator is available on their site. Features include:

- Front office solution to deal with patient registration, forms, appointments, check-in and patient messaging
- Back office solution for online bill payment, billing messaging and a virtual credit card payment system
- Clinical solution includes med renewal and refills, secure messaging, personal health records, referral management, virtual visits, symptom assessment, lab results and reminders[41]

ReachMyDoctor. This site is aimed at improving communication with the doctor's office and offers two options:

- Free: schedule appointments, request medication refills, request a referral and address billing and insurance issues
- Subscription: for $8.95 monthly a patient can ask the physician non-urgent questions via secure e-mail. Physicians must be part of the network[42]

My HealtheVet. A 2008 portal that integrates with the Veterans Affairs EHR and offers lab results, wellness reminders, appointments, a personal health record (PHR), medication refills, patient education and online monitoring of: activity, food intake, oximetry, blood pressure, glucose and weight. In the future there are plans to include online appointments, online payments and limited access to the EHR.[43]

Personal Health Records (PHRs)

PHR Definitions

According to the American Health Information Management Association (AHIMA) the personal health record (PHR) is:

> *"an electronic, universally available, lifelong resource of health information needed by individuals to make health decisions"*[44]

The National Alliance for Health Information Technology defines a PHR as follows:

> *"an individual's electronic record of health-related information that conforms to nationally recognized interoperability standards and that can be drawn from multiple sources, while being managed, shared controlled by the individual"*[45]

Introduction

The Institute of Medicine promotes PHRs by stating "*patients should have unfettered access to their own medical information*"[46] The first principle endorsed by the Personal Health Technology Council is that "*individuals should be able to access their health and medical data conveniently and affordably*".[47]

Interest in PHRs comes from multiple sources. In 2002 the Markle Foundation established *Connecting for Health*, a public-private collaboration to promote better information sharing between doctors and patients. In their July 2004 position paper they suggested: PHR development should be increased, PHRs will educate patients about their health and common data standards are a logical starting point. In one of their surveys 61% of respondents agreed that they should have access to their medical information "*anytime, any place*".[48] A 2004 Harris Interactive survey of over 2,000 adults demonstrated that 42% kept personal or family health records but only 13% stored their records electronically.[49] Another survey conducted in 2004 by Bearing Point noted that over 50% of respondents would be interested in carrying their medical records in a portable device, accessible in an emergency.[50] The Centers for Medicare and Medicaid Services released a Request for Information (RFI) about PHRs in July 2005 to determine its future direction.[51] They are well aware of the need for better patient information sharing and storage in older patients who are on multiple medications and have multiple physicians. In 2005 attention was given to electronic health records and personal health records after hurricanes Katrina and Rita. As a result, Blue Cross/Blue Shield of Texas created personal health record-like summaries of care from insurance and pharmacy claims data, available to both physicians and patients.[52]

Ideal PHR Features

In spite of the fact that PHRs are new and are available in many formats, experts believe that PHRs should have the following features in order to be successfully adopted:

- Portable, meaning that the information will follow you even when there is a job, insurer or clinician change. Another argument for portability is the fact that, on average, 41 million Americans move each year [59]
- Interoperable, meaning the PHR format can be shared among disparate partners. A standard such as the CCD would have to be adopted
- Autopopulated, which would mean that clinical and test results would be inputted automatically
- Controlled by the patient
- Longitudinal record and not just a snapshot
- Private and secure
- Must fit into clinician's workflow and not be a separate process
- May benefit from being certified

The reality is that no organization has the ideal solution, with all of the above features.[53-55] In the following section we will discuss the current choices, organized by format.

PHR Formats

Tethered. The word tethered implies that the PHR is connected to one platform and not interoperable. The earliest and most common examples of this would be claims-based PHRs from insurers and healthcare organizations. Other examples would be PHRs tethered to an EHR or standalone patient portal. Payer-based PHRs have the advantages of being free to patients and easy to populate with claims data. They have the disadvantages of not being portable or interoperable

and not controlled by patients. Moreover, claims data is always several weeks old and usually tells you that a test was ordered and does not provide the actual results. Furthermore, the payer-based PHR is not longitudinal because it likely only covers patient encounters insured by their company.[54]

In late 2006 America's Health Insurance Plans (AHIPs) and Blue Cross/Blue Shield Association announced a comprehensive plan to supply PHRs to their members by 2008. Importantly, the established core data standards determined that much of the information would come from claims and administrative data. With established data standards PHRs can be shared between different insurance companies, should a patient move or change coverage.[56-57] Aetna has offered its PHRs to 6 million of its 37 million members. In 2008 they also offered their PHR to Medicare plan enrollees. Of interest, they will use *CareEngine,* a software rules engine that reviews the claims-based PHRs and gives personalized alerts (called care considerations) to patients and physicians about how to improve medical care.[58]

Untethered PHRs. Untethered PHRs imply they are not connected to one platform and there have more interoperability potential. PHR programs are available in multiple mobile and static platforms. There are more than fifty untethered personal health record products on the market, giving consumers many choices but obvious limitations.[59]

- Web based. Most are commercial sites that are secure and can be accessed from a distant site. A minority of PHRs reside in patient portals that connect to an electronic health record system.
- Mobile technology. Patient information can be downloaded to:
    - Secure digital cards and USB drives: Most USB programs synchronize to a web based portal where patient information is also stored. Mobile technology offers several unique advantages. It is not dependent on the Internet for operation and is truly portable but not interoperable. In 2006 a new USB drive in the form and size of a credit card with memory up to 2 GB[60] appeared and is now available as a PHR[61]
    - Smart Phones: Given the soaring popularity and expanding features of smart phones they may become the mobile storage of choice.[62] Blue Cross of Northeastern Pennsylvania will provide members secure electronic access to their medical records via a web enabled smart phone. The information will be derived from claims data and patient input. The program will use *MobiSecure Wallet and Vault* to access the Internet and authenticate the user.[63] Another example is MyRapidMD that downloads a client's emergency medical information to any Java enabled cell phone. Membership includes a wallet card, phone sticker, windshield sticker and key chain cards[64]
    - Smart Cards: The United States has been slow to use smart cards in the field of medicine, unlike countries like France and Germany. Most smart cards are used for patient authentication in the healthcare environment. Most smart cards can hold 64 KB-144KB of information (60 plus pages of single spaced text). These cards have a small processor that can be programmed to do several tasks such as encryption and are re-writable. Cards can be read by contact or be contactless, using radio frequency (RF). They have the potential to speed up electronic claims submission by decreasing clerical errors. In 2007 Mt. Sinai Hospital began a pilot project and issued about 14,000 cards to patients in the New York City area. In 2008 they decided the cards should have open standards, such as the Continuity of Care Record (CCR), to record patient information on the card. This would make it interoperable with other

entities. The card is updated every time it is placed in a card reader and autopopulates with demographics, lab results, etc.[65] Another issue with current healthcare cards is that they are not standard and as such are not readable by all readers. Medical Group Management Association (MGMA) is promoting an industry-wide effort known as ProjectSwipeIT to standardize these cards, even though they are not truly smart cards.[66] For more details about smart cards in healthcare we refer you to this 2009 monograph[67]

- Personal Health Record Systems is an arbitrary term to indicate an untethered PHR that is interoperable. The following are the major examples of these systems:
    - Google Health: Google entered the PHR market in 2008 with a pilot project with the Cleveland Clinic and subsequently made their product available to the public in May 2008. Their product is known as Google Health and offers a very simple patient interface that includes a medical topics search engine, discussion boards, drug-drug interaction engine and a do-it-yourself PHR. You can opt to share your record with others and get an activity report. You can also print a wallet-sized PHR. More details about how developers and vendors can connect to Google Health using their application programming interface (API) can be found under Google Code. At this point they support the Continuity of Care Record (CCR). In 2009 Google announced that they will partner with IBM to design software so patients can upload device data (like blood sugar results) to their PHR.[68] Google maintains that there will be no advertising or selling of patient data. Once you create your personal profile you can link the profile to external services. As of June 2009 the following links were offered:
        - Personal health services offers connections to nine services. Each service requires you to register with a username and password and permission to link to your information. Each takes advantage of your profile. As an example, a link to TrialX.org provides you information about what investigational trials exist to match your medical history
        - Import Medical Records links to fourteen services; nine are pharmacy related, one is lab related and the remainders are healthcare organizations. These services allow you to import your records to Google Health. All services to convert paper records to Google Health are fee based. One interesting service is Epocrates Patient Snapshot that allows an Epocrates participating physician (with the patient's permission) to access a patient's profile on Google Health. Unfortunately, there is no easy way for a patient to upload their personal documents, such as an EKG
        - Find a Doctor permits searching by name, specialty or location[69]
    - Microsoft HealthVault: Microsoft announced in 2007 that they would offer a free service known as HealthVault. It is not a PHR, but is instead a means to upload and store health information. You must register for other free or fee-based programs to upload information such as blood pressure or glucometer results. Microsoft has announced that it will release the source code of the HealthVault.NET Software Development Kit and the XML interfaces under the Open Specification Promise (OSP). This will enable third party developers to develop HealthVault compatible applications. The goal would be to interface with all electronic health records in the future. In mid-2008 Kaiser Permanente began a PHR pilot project with its 156,000 employees. They will link their information with Microsoft's HealthVault using the

Continuity of Care Document (CCD) standard (discussed in chapter 4). If this pilot project is successful, they will decide whether to offer it to their 8.7 million members.[70] Microsoft has also established a Be Well Fund of $3 million to promote technology innovations in the area of primary and secondary prevention, acute care and juvenile disease management. The ultimate goal of the Fund is to create new patient centered technology tools that will store their information in Microsoft's HealthVault.[71] The Cleveland Clinic will test HealthVault as well as Google Health. They plan to enroll 400 patients in a pilot study to test home devices to better manage chronic diseases. The PHR would then transfer information to the Cleveland Clinic's EHR Epic® system.[72]

- Dossia: The system was founded by Applied Materials, BP America, Intel, Pitney Bowes and Walmart with data derived from insurers, pharmacies and physicians. The system known as Indivo is hosted by Childrens Hospital in Boston and consists of a free open-source, open standards platform. Application programming interfaces (APIs) are available to developers for customization. Indivo handles both CCR and CCD documents. They plan to interface with EHRs, patients, physicians, researchers, health information organizations and public health services.[73] More details about this application were reported by Mandl et al in the literature.[74]
- MiCare: In 2008 the Military Health System began a pilot PHR program known as MiCare at Madigan Army Medical Center. They will download 24 months of demographics, med lists, allergy data, lab and x-ray results, appointments and visit documentation from the military electronic health record known as AHLTA for 250 test patients. At this point, patients have the choice of storing the information in Microsoft HealthVault or Google Health. They plan to expand to additional locations and add secure messaging.[75-76]

How are PHRs interoperable?

The following scenario is taken from the *HITSP Consumer Empowerment and Access to Clinical Information via Networks Interoperability Specification* monograph. A patient signs on to e.g. Google Health to establish his or her PHR. He/she also adds information on the spouse and states that the spouse and primary care physician (PCM) have permission to access his/her medical information. With the patient's permission Google Health establishes relationships with the patient's health information exchange (HIO), the primary care physician's EHR, the local drug store, the pharmacy benefits manager and any insurance company. When he arrives at his PCM's office, instead of filling out the standard paper registration forms, the office staff retrieves updates to their EHR by accessing his PHR via the HIO. Medications, allergies, etc are available to retrieve as well.[77] This implies data standards as well as document summaries such as the CCD are in place. This scenario also depends on ubiquitous EHRs and HIOs as well as mature information networks. It is likely that this conceptual model will take time and substantial resources to become a reality. Figure 6.3 demonstrates the potential interoperability of PHRs with the rest of the healthcare system

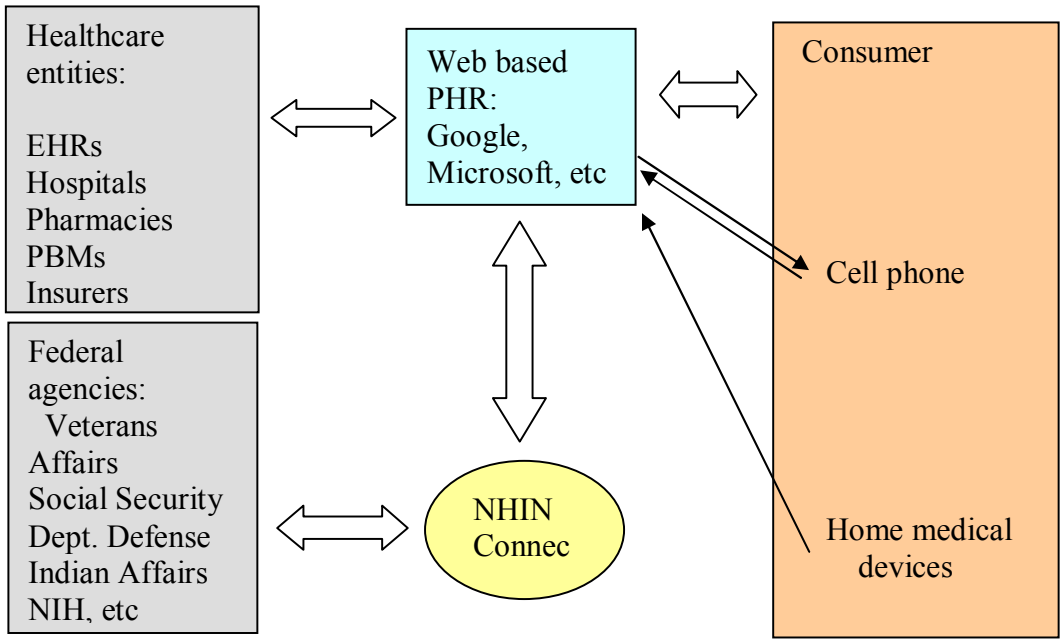

Figure 6.3 PHR Interoperability of PHRs with multiple federal and non-federal partners (PBM = pharmacy benefits manager)

PHR Research Questions

Kaelber et al published a very helpful article in December 2008 titled "A Research Agenda for Personal Health Records". They correctly point out that there is very little published about the impact of PHRs on patient behavior and outcomes. They believe research is needed to answer the following questions:

1. What PHR functionality is needed in the areas of data collection, sharing, exchange and self-management?
2. What is needed to improve adoption of PHRs by patients and clinicians? Research should focus on specific populations like the elderly, patients with chronic diseases, etc.
3. What is needed to ensure privacy and security?
4. What PHR architecture or model is likely to be most effective? Tethered? Untethered?
5. What is the business case for PHRs and are the incentives aligned for patients and physicians? [78]

Thus far, personal health records have been voluntary, placing the burden of downloading and maintaining health information on the patient. A busy physician's office is not likely to want this additional responsibility without reimbursement. The vision is to have records stored in repositories like Google Health in a format (XML) that is compatible with EHRs, HIOs, etc., but this will likely take years to accomplish, for those patients who are interested. As PHRs develop more user friendly features, perhaps the appeal to the average consumer will increase. Some PHRs, for example, will provide alerts such as "medications about to expire" or "upcoming medical appointments". An ideal business model for personal health records does not exist. Some studies suggest patients are willing to purchase their own PHRs if the price is low and others suggest insurance companies are the

entity most likely to play a major role. Theft of personal health information (PHI) is a definite concern to the average patient and personal health records is just one more platform of concern.

At this time it appears that patients are lukewarm about personal health records, regardless of format or who picks up the bill. A 2006 survey of more than 11,000 American and Canadian consumers demonstrated that 22% of patients have not used the PHR feature offered by their insurance company and 53% had never accessed their health plan's web site. Thirty four percent interviewed did not trust the site's security and 29% did not see benefit from the concept of the PHR.[79] In a similar 2007 survey by Aetna, only 36% of those surveyed were familiar with PHRs and of those only 11% used one to track their medical history.[80] It will take time to determine the impact of PHRs and what incentives actually are important to patients and other members of the healthcare team. There are healthcare consultants who believe that PHR systems have a brighter future than HIOs for future data interoperability, but both suffer from inadequate business models and consumer enthusiasm.[54]

Other countries such as England are dabbling with the issue of PHRs for its citizens. They created HealthSpace in 2003 to store health notes, book appointments, store physiological parameters such as blood pressure and access National Health Service (NHS) contacts and health links. By late 2008 they allowed access to the NHS Summary Care Record that included allergies and medication histories.[81]

Several PHR research projects are worth mentioning:

- Medicare plans to determine whether PHRs change patient outcomes or save costs. The vendors selected are Google Health, Health Trio, NoMoreClipBoard and Passport MD. The one year program known as Medicare PHR Choice should begin in 2009 for patients located in Arizona and Utah. CMS will transfer up to 2 years of Medicare claims data upon request. Medicare will partner with HIP USA, Humana, Kaiser Permanente and the University of Pittsburgh Medical Center. Each plan will have a unique PHR that allows patients to access their own information. It is anticipated that the information will derive from hospital and physician claims data. Medicare will also pilot a PHR program in South Carolina in this same time frame using claims data.[82-83]
- Robert Wood Johnson Foundation created Project HealthDesign to study PHRs that deal with chronic diseases such as breast cancer, diabetes, chronic pain, etc using nine research teams. The final report for round one is still pending. The second round of calls for proposals ended in June 2009.[84]

Secure Patient-Physician E-mail and E-visits

"Digital Rx: Take two aspirin and e-mail me in the morning"
New York Times 3/2/2005

Secure patient-physician e-mail communication

The vast majority of Americans today use e-mail, however few physicians routinely use e-mail to communicate with their patients.[85] According to a 2005 survey by Harris Interactive, 80% of patients who go online would like to communicate with their physicians.[86] On the other hand, in another survey in 2005 by the Center for Studying Health System Change, 24% of physicians surveyed used e-mail to communicate with patients,[87] compared to 3.4% reported in a 2004 study.[88] Furthermore, 41% of respondents in a 2001 Harris Interactive study found it very frustrating to see a physician in person when they thought a telephone call or e-mail would suffice.[89] Multiple studies suggest patients want to communicate with their physicians via e-mail but that enthusiasm is not

shared by most physicians.[90] Physicians cite the following reasons for not using e-mail: liability (56%), poor compensation (45%), privacy issues (43%), staff not trained (30%) and the feeling that face-to-face visits are better (27%).[91] Patients are seeking better service by wanting to use e-mail but their expectations might be unrealistic. In a survey of 950 primary care patients in Texas, 62% of respondents expected the results of their lab results by e-mail in less than 24 hours.[92]

Multiple benefits of e-mail communication have been pointed out. The communication is asynchronous so physicians can answer at their convenience and avoid "*phone tag*". Overhead is lower for electronic messages compared to phone messages and they are self-documenting. Patients tend to lose less time from work for minor issues. It is preferable to communicate with patients using secure messaging through a web based third party where authentication is validated, not true for routine e-mail. An October 2007 article in Pediatrics reported that physician-parent e-mail communication was 57% faster than telephonic communication and resulted in high consumer satisfaction. Forty percent of e-mails occurred afterhours but only amounted to 1-2 e-mails per day. It should be noted that the only physician involved was a pediatric rheumatologist and not a generalist. Also, only one third of families offered e-mail communication took advantage of it. It is therefore difficult to generalize these results to the average physician's office.[93]

Potential disadvantages of e-mail messaging might include: indigent patients less likely to use the service; inability to examine the patient; potential for communication errors; possible slow responses; security issues and the potential to be overwhelmed.[94-95] Thus far, these concerns have not been borne out by published studies.

Electronic visits

Electronic visits (e-visits or virtual visits) are an example of telehealth or telemedicine where medical care is delivered remotely (telemedicine is covered in much more detail in chapter 18). Virtual visits are available as a continuum of care. In other words, there are multiple ways a patient can communicate remotely with a clinician. The web-based choices for patients might include:

- **Secure messaging** and templates to input a health concern and wait for a response by a clinician
- **Telephonic communication** (audio) to communicate with clinicians
- **Audio and video** to state a concern and show, example, a rash

Secure messaging: E-visits require secure messaging and not routine e-mail. This has the advantage of much better security and privacy and the ability to have a third party involved in the billing process. Patients and physicians must utilize a username and password to log onto a secure web site in order to conduct an e-visit. Numerous vendors such as RelayHealth and MedFusion provide the platform for e-visits in addition to their patient portal features. Some authorities feel the e-visits have a bright future. A Price Waterhouse study estimated that 20% of outpatient visits could be eliminated by using e-visits.[96] A new CPT code 0074T was developed for e-visits.[97] Nevertheless, e-mail conduct guidelines have to be established to prevent abuse.[98] Guidelines also need to be established to define what constitutes an e-visit in order for insurance companies to reimburse for the electronic visit.

Several reports address how e-mail and e-visits might impact a physician's productivity.[99-101] A 2007 report from the Kaiser-Permanente system suggested that e-mail communication decreased office visits by about 10%, compared to a control group, which could decrease a physician's income. Had the e-mail communications been reimbursable as an e-visit, this might not have been the case.[102] The consensus is that minor complaints can be dealt with more efficiently electronically, thereby allowing sicker patients to be seen in person. It has also been pointed out that

if the patient provides a history during the e-visit and still has to be seen face to face, the physician has the advantage of knowing why the patient is there, therefore saving time.

In spite of the enthusiasm for e-mailing physicians, most patients are not willing to pay more than minimal co-pays for an e-visit.[103] In a study by RelayHealth they were able to demonstrate that, compared to controls, the patients who had e-visits had lower insurance claims. The profit more than paid for the $25 physician charge and the $0-10 patient co-pay. Importantly, 50% were less likely to miss work and 77% said it only took 10 minutes for the e-visit. Patient and physician satisfaction levels were good.[104] Pilot projects and studies are underway to evaluate e-visits. BlueCross/Blue Shield of Tennessee and other regions are reimbursing physicians for electronic visits.[105-108] The University of California at Davis Health System has been performing e-visits since 2001 and states that 80% of insurance companies in their region support the concept. Participating physicians seem to be more cost effective and physicians are receiving bonuses.[109] Cigna's HealthCare for Seniors program now covers electronic visits for older patients using the RelayHealth portal. Non-seniors must pay a fee for e-visits.[110] In January 2008, Cigna and Aetna announced that they would expand their virtual visit pilot programs to the rest of the nation. Cigna will pay $25-35 for an online consultation and the patient would pay their co-pay with a credit card via RelayHealth. Aetna will have a similar program that will include 30 specialties. These payers are also looking at discounts to physicians using RelayHealth as an incentive to offer virtual visits.[111]

A new free secure messaging service is available and known as HouseDoc. It would permit a virtual asynchronous visit, a request for medication refills, a request for appointments and test results. If the clinician charges the patient, the web service charges $2 and services are paid for by credit card.

An excellent review of Patient-Provider communication can be found in a 2003 monograph by the First Consulting Group[112`]

Telephonic visits: The concept of virtual visits has spawned innovation in the delivery of healthcare. As an example, TelaDoc is a telephone based consult service that is intended to supplement the care delivered by the primary care physician. This web based application guarantees a clinician will return a phone call in 3 hours and the average charge is $35. They claim to have 1 million members and offer services 24/7. The clinician will prescribe and handle refills but not prescribe narcotics or order labs. Interestingly, they save the patient encounter as a continuity of care record (CCR) type document that can be shared with others and accessed at the next visit.[113]

Audio-Video Televisits: Another innovative virtual visit service worth mentioning is American Well. Patients can interact with clinicians using web-based videoconferencing, as well as secure chat and telephonic communication. They are promoting 24/7 access for patients from home and aim to coordinate care with the primary care clinician (PCM) and insurance company. The service locates an appropriate clinician (including specialists), initiates a live audio-video conversation with a clinician and forwards the results to the PCM. For the clinician there is automatic claims submission and a per-consultation malpractice insurance coverage is offered. In addition, clinical practice guidelines are promoted for standardized care, known as online care insight. The approximate cost for an e-visit is $45.[114]

Key Points

- Consumers are becoming more sophisticated and more demanding towards all services, including healthcare
- Patients would like to have the same automation and convenience of an ATM machine applied to healthcare
- Patients are using the Internet as the medical library of choice before and after seeing clinicians
- Patient web portals are now available that are standalone or integrated with electronic health records that offer a multitude of patient oriented services
- Everyone is talking about personal health records but it is unknown who will pay for them and how information will be integrated with electronic health records and other information systems
- Secure patient-physician e-mail and e-visits have great potential to expedite acute care visits once reimbursement becomes the standard

Conclusion

Many patients have cast their vote in favor of a more user-friendly healthcare system. They desire rapid access to medical answers via the Internet and rapid access to their healthcare system through their web portal. They would like to have storage of their personal health information somewhere but are reluctant to pay for it. Information technology giants like Microsoft and Google have entered the Health field with an uncertain long term effect. Lastly, patients want to communicate with their clinicians via secure messaging and if necessary initiate an e-visit. It will take time to see if patients, clinicians and payers align to make this a reality. If patient satisfaction becomes associated with reimbursement or incentives then we can expect multiple consumer centric healthcare innovations to appear. This will be aided by faster and cheaper video teleconferencing.

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7

Online Medical Resources

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Learning Objectives

After reading this chapter the reader should be able to:

- State the challenges of staying current for the average clinician
- Describe the characteristics of an ideal educational resource
- Describe the evolution from the classic textbook based library to the current online digital library
- Compare and contrast the different formats of digital libraries
- Describe the future of digital resources integrated with electronic health records
- Describe emerging Web 2.0 technologies in medicine
- Identify the most commonly used free and commercial online libraries

"Knowledge is Power"
Frances Bacon 1597

"The complexity of modern American medicine is exceeding the capacity of the unaided human mind"
David Eddy

Trying to keep up with the latest developments in medicine is very difficult, primarily due to the accelerated publication of medical information and the significant time constraints placed on busy clinicians. It is likely that clinicians are in fact so busy that they have no idea what new educational resources are available to them. They would like to move from the "information jungle" to the "information highway" but who will show them the way? This chapter is devoted to those clinicians who are seeking rapid retrieval of high quality medical information.

What are the challenges clinicians face today?

- **Educational Challenge**. More than 460,000 articles are added to Medline yearly.[1] The 2009 Physicians' Desk Reference (PDR) is over thirty three hundred pages long making it exceedingly cumbersome to search for drug information.[2] This presents a disincentive for searching for drug information and it is therefore a patient safety issue. Standard medical textbooks are expensive and out of date shortly after publication. In addition, some argue that the descriptions of diseases are not always updated or evidence based.[3] Moreover, Shaneyfelt estimated that a General Internist would need to read 20 articles every day just to maintain present knowledge.[4] Physicians find it difficult not to think of themselves as experts and it often shakes their confidence, but a new confidence can be found in knowing how to locate needed information.

- **Specialty to Primary Care Manager (PCM) Challenge**. Recommendations from specialty organizations take time to trickle down to the generalists. There is no standard way to disseminate information that is either reliable or particularly effective. National guidelines, usually written by specialists, face the same challenges. Once there is a new standard of care for a disease such as diabetes, how do you get the word out, particularly to small or remote medical practices?
- **Translational Challenge.** Studies have shown that it may take up to ten or more years for research to be "translated" to the exam room (e.g., thrombolytics).[5] In a study by Antman, experts were also slow to make recommendations in textbooks even though high quality evidence was published many years prior.[6] On the other hand, many physicians are skeptical and wait for confirmatory studies. If they have been in practice for many years, they may have witnessed the pendulum sweep back and forth regarding, for example, the use of post menopausal estrogens. Recent studies often contradict older studies due in part to better study design and larger subject populations.[7]
- **Evolutionary Challenge.** We can no longer teach "*classic medicine*," because diseases and their presentations change over time as demonstrated by new presentations for infectious diseases. Rocky Mountain Spotted Fever began to disappear as Lyme disease began to appear. Additionally, diseases were detected at more advanced stages in the older literature, because lab tests were lacking, making clinical presentations more dramatic. Currently we tend to diagnose diseases earlier, before the patient has advanced signs and symptoms due to better and earlier tests. Medical resources therefore must reflect new evidence.
- **Retention Challenge.** According to many studies there is an inverse relationship between current knowledge and the year of graduation from medical school. Ramsey compared board scores of Internists and the number of years elapsed since certification and demonstrated this inverse relationship.[8]

How often do clinicians have patient related questions and find the answers?

- Covell reported that on average Internal Medicine physicians had two questions for every three patients seen and found the answers for only 30%.[9]
- A study by Ely showed that Family Medicine physicians had 3.2 questions per 10 patients seen. The answer was pursued in only 36% of cases.[10]
- In a primary care survey Gorman noted 56% of physicians pursued answers where they thought an answer existed and 50% of answers dealt with an urgent issue. Most physicians turned to other physicians for answers and not the traditional medical library. Lack of time was the universal reason not to pursue answers in most studies.[11]
- In another study by Ely, the most common questions dealt with drugs, Ob-Gyn and adult infectious disease issues. Answers to 64% of questions were not pursued and physicians averaged less than two minutes per search. The most common resources used were books and colleagues and only two physicians performed literature searches.[12] All of the above studies evaluated primary care physicians, so the needs of other physicians, such as surgeons and specialists, are less clear. Also, after these studies were published software programs such as Epocrates appeared and significantly changed how we seek drug information.

What is the state of medical libraries today?

When describing a recent visit to the library in his article, "Quiet in the Library," Lee speaks of the quiet created as a consequence of physicians no longer needing to go to the library to do research. Lee speaks of the transition that is taking place in medical education where emphasis is no longer on developing physicians that know everything, but rather as practitioners who can find and use information when it is needed. Although today's medical libraries provide timely, pertinent and authoritative knowledge-based information in support of patient care, education and research, a significant percentage of the journal and textbook literature has migrated from print to online during the last decade. Physicians can research their clinical questions from their desktops without going to the library.[13-14] Burrows in a paper reviewing electronic journal use at the Louis Calder Library at the University of Miami School of Medicine reports an 88% decrease in the use of print journals in the period from 1995-2004.[15] Libraries have moved their collections online and re-designed stack space into study areas, computer workstations and collaborative areas.

How have we evolved from the traditional library to online resources?

Within a very short time the Internet has become the educational resource of choice due to the speed of retrieval and depth of information. A 2001 study by the American Medical Association showed that 75% of physician practices had Internet access and 79% used it to research answers. Three out of ten medical practices had their own website.[16] These statistics continue to rise as does the availability of broadband access. Patients' using the Internet as an online library has closely mirrored the pattern of physicians. The Internet now hosts more than 3 billion web sites. As an indication of growth, a Google search for the words "*medical education*" in 1995 by one of the authors yielded 760 results,[17] whereas a search in 2007 yielded about 10 million citations. Although The 21st century searcher is at the center of a virtual library, he or she must cope with the quantity of easily retrieved information and be capable of evaluating that information for reliability, currency and authority.

Before the advent of the Internet physicians used print resources for verifying factual information related to patient care, sought insights from their colleagues on difficult cases and performed library research on exceptional cases themselves or with the aid of medical librarians. The nature of physician information-seeking has not changed substantially in the last decade, but mode of access to resources has changed dramatically. To provide the best care for their patients, physicians still need to check drug information, differential diagnosis tools, current textbooks, or the journal literature, but instead of heading to the library they turn to the Internet for answers. The resources available online are far more extensive than the personal libraries or hospital libraries that physicians used in a print world.

Reference materials in the twenty-first century have been migrated to online formats. Drug information compendia, laboratory references and textbooks have been converted to electronic formats, although only the major references and texts are available online. Two types of online journal have emerged: the electronic version of the print journal and the born-electronic journal. Either type can be open access (free to all users) or available by subscription only. Recently publishers are experimenting with hybrid journals that offer their most important content online, while still publishing print issues. Although many predict the demise of the print journal, the transition phase may last another decade. Today medical library collections are a mosaic of print and online content, but the mission of the medical library remains the same. Medical libraries today provide more extensive offerings than the print collections found in most hospital libraries a decade ago, but these resources are expensive and strictly controlled by site licenses. To have access to the most authoritative information a well-informed physician still needs to have an affiliation with a

medical library or be willing to read premium medical content on a subscription or pay per view basis.

Journal indexes were the pioneers of research online. The Medline database that today has over 16 million citations from over 5,000 journals searchable online began in 1966 as an electronic archive of citations to the medical literature that was only searchable by highly trained librarians. When MEDLINE introduced end-user searching in the pre-Internet era citations previously accessed manually through the *Index Medicu*s were available directly to clinicians at their desks. Although end-user searching revolutionized access to the journal literature, it was limited to titles and abstracts. With the advent of the Internet came online journals and the ability to link the full-text journal articles to Medline citations. Despite these improvements Medline searching still is not an easy path to high quality, quick answers to clinical questions. Several studies have shown that finding an answer is difficult and takes too much time for a busy clinician.[18-19] A pertinent abstract might be located, but it requires additional time to obtain the full-text whether it be from a free or fee-based online source or through the medical library. A Medline search should be reserved for rare medical problems, research, writing a paper or creating a clinical practice guideline (CPG). Medline will be discussed in more detail in the chapter on search engines.

In 1994 Shaughnessy stated that the usefulness of medical information is equal to the relevance times validity divided by the amount of work to access it.[20] A 2004 study in the journal *Pediatrics* comparing retrieval of information from online versus paper resources showed it took eight minutes for an answer via an online resource as compared to twenty minutes using traditional paper based resources.[21] There is little doubt about the tremendous potential of online resources for speed of access, but the quest to find the precise, authoritative answer to a clinical question within the limitations of a patient visit remains elusive. Turning to resources of known quality appeared to be an efficient choice, so converting traditional resources to online formats was the logical first step.

Harrison's Online (the online version of *Harrison's Principles of Internal Medicine,* 17th edition) and Scientific American Medicine (now known as ACP Medicine) were among the first online full-text resources. The online versions of these popular textbooks are continually updated and are accessible from anywhere. Many libraries offer online access to these textbooks and individuals may purchase subscriptions to the online versions at about the same cost as copies of the print textbooks. Recent online versions offer a variety of subscription options and offer their content through several portals. The print edition of *Harrison's Principles of Internal Medicine,* 17th edition, published in 2008, offers supplementary material on DVD and is using RSS feeds and podcasts to disseminate its updates. Although these textbooks make valuable expert knowledge easily accessible, their main drawback is that they tend to cover only the basics about any subject and therefore lack depth. In spite of the fact that they have a search engine, like a standard textbook a reader may have to review multiple book chapters to find the answer.

More comprehensive aggregated resources followed the advent of online textbooks. MDConsult, Medscape, StatRef, and OVID were created to offer multiple resources such as books and journal articles, patient education materials, medical calculators and medical news in one product. Searches of these, otherwise excellent, resources yield multiple references to the full-text of various documents that must be analyzed to find the answer to the clinical question. You might have to read twenty book or journal pages to finally find the answer. This is not optimal if you are seeking an answer while the patient is still in the exam room.

Ideal medical resources are those that are:

- Evidence based with references and level of evidence (explained in the chapter on evidence based medicine)
- Updated frequently
- Simple to access with a single sign-on

- Available at the point of care
- Capable of being embedded into an electronic health record
- Likely to produce an answer with only a few clicks
- Useful for primary care physicians and specialists
- Written and organized with the end user in mind

According to Richard Smith the "best information sources provide relevant, valid material that can be accessed quickly and with minimal effort".[22] The need for a synthesized resource that can easily provide evidence-based answers to questions during the patient visit has given rise to several excellent, focused resources, often referred to as point of care resources or bedside information products. UpToDate, eMedicine, DynaMed, ACP-PIER and FirstConsult present their content, so that clinicians can answer clinical questions with current, comprehensive and rapid retrieval. These products focus on patient-oriented information and differ in the number of topics covered, the way the evidence is documented and the organization of the material. UpToDate, Essential Evidence Plus (formerly InfoRetriever), ACP Pier, Diseasedex, DynaMed and First Consult have been very well received, and clinicians develop their preferences among these offerings based on user interfaces and the ability of the database to answer questions. In an evaluation of five bedside information products, Campbell and Ash took a user-centered, task-oriented approach to testing the ability of these products to answer clinical questions. The study rated UpToDate the highest in ease of interaction, screen layout and overall satisfaction and found that users were able to answer significantly more questions quickly with UpToDate[23]; however, other researchers have found that users have preferred resources such as ACP Pier and Essential Evidence Plus, because of the way evidence levels are documented.[24]

- A 2004 study showed that 85% of medical students easily transitioned from traditional resources to primarily online medical resources (UpToDate and MDConsult).[25]
- In a report published in 2005, Internal Medicine residents were able to find answers 89% of the time and the information changed patient management 78% of the time. The most common resources accessed were UpToDate and Medline.[26]

Use of the point-of-care tools discussed above begins with a diagnosis. In a controversial article in BMJ Tan and Ng reported that Google could function as a useful diagnostic aid. [27] Others would argue that specially designed tools such as the new generation of clinical decision support systems are more appropriately designed to improve medical diagnosis and reduce diagnosis errors by directing physicians to the correct diagnosis. Although clinical decision support systems have been around for years the new generation of tools as exemplified by *Isabel* (Isabel Healthcare) has been shown to suggest the correct diagnosis in approximately 96% of adult patients when tested with 50 consecutive Internal Medicine case records published in the New England Journal of Medicine.[28] Tools such as *Isabel* by assisting the physician in making the diagnosis provides an entry point into the literature and can link clinicians to resources such as UpToDate, PubMed and more in order to obtain information in depth on the case at hand.[29]

Several medical resource vendors are in the process of making the leap towards having the resource embedded into electronic health records. Examples would include iConsult, Dynamed, UpToDate and ACP-PIER to mention a few. The flow diagram below plots the evolution from the traditional to the online medical library.

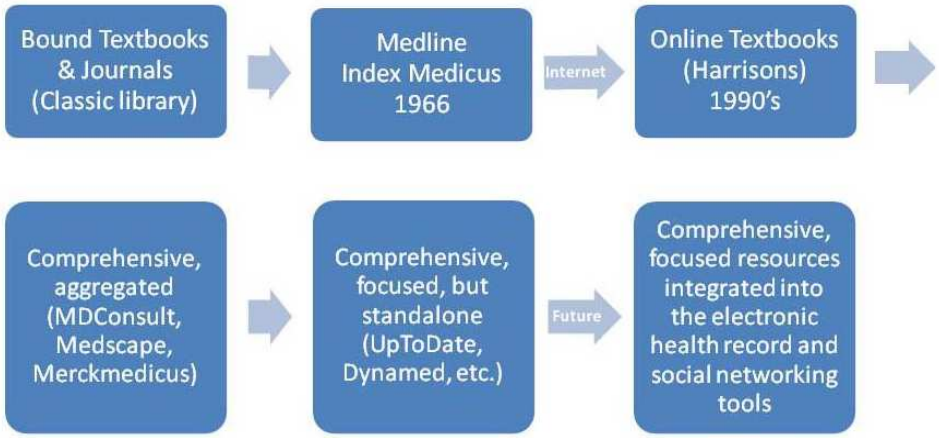
Bound Textbooks & Journals (Classic library)
Medline Index Medicus 1966
Internet
Online Textbooks (Harrisons) 1990's
Comprehensive, aggregated (MDConsult, Medscape, Merckmedicus)
Comprehensive, focused, but standalone (UpToDate, Dynamed, etc.)
Future
Comprehensive, focused resources integrated into the electronic health record and social networking tools

Figure 7.1. The evolution from traditional to online medical libraries

What new tools are available to stay current in medicine ?

Many of the medical information resources described above mirror print resources and are written and designed to be read as questions arise. Lee mentions in his article "Quiet in the Library"[13] that "*the flood of new information and the demands of simply getting through the day have become so overwhelming that many physicians no longer find the time for 'lifelong learning' through such activities as reading journals or attending grand rounds.*" To keep their medical practice current physicians need new tools. Interactive web technologies, known as Web 2.0, have emerged that allow knowledge sharing among users and allow customized content to be distributed to interested users. These tools can be harnessed to help physicians learn about the very developments that will improve their practice.[30-31]

Weblogs or blogs, websites that build content through dated entries, have generated large repositories of focused medical content. Web 2.0 technologies hold the promise of an enriched learning environment enabled by collaboration on a large scale. Blogs such as *Kevin MD*, *Clinical Cases and Images* have developed large readership and through the dialog between bloggers and readers physicians are discovering new ways to learn.

Wikis (the name comes from the Hawaiian word meaning quick) allows physicians to collaborate to create peer-reviewed content that is written and edited by participating users. The most famous general example is Wikipedia, but several medical references such as AskDrWiki.com and Ganfyd.org are being created and shared by participating medical professionals. AskDrWiki controls the quality of its entries with strict editorial policies and Ganfyd only allows credentialed individuals to provide content.

Keeping up with changes to important websites can be challenging. Really Simple Syndication (RSS) can make that process manageable. RSS is a format that delivers changes from multiple websites to one place. RSS allows physicians to request content from various websites and read that content in single place, known as an aggregator. Subscribe to an aggregator such as MedWorm or Bloglines, the look for the RSS icon at a website. Subscribe to RSS feeds of interest and read them with the aggregator. Physicians are using RSS to receive textbook and website updates, Pub Med search results, journal tables of contents and medical news.

Audiocasts (podcasts) and videocasts offer educational programs, health news and medical updates. New England Journal of Medicine now offers weekly article summaries via podcasts and Johns Hopkins University offers weekly health news podcasts. To subscribe to multiple podcasts you will need to subscribe to an audio aggregator, known as a podcatcher. Choosing a podcatcher

can be confusing. Podcatcher Matrix will assist you in choosing a podcatcher that is compatible with your operating system and mobile device.[32]

Sponsored Medical Web Sites

Multiple excellent web sites are available that are either sponsored or fee-based. Most of the sites discussed in this section have multiple features that continue to improve. Medical education traditionally has been based on reading journals or textbooks, but can also involve the presentation of interesting and unique cases. A thorough discussion of this alternative approach appeared in the February 2007 Mayo Clinic Proceedings.[33]

Medscape

- An all purpose medical web site
- Covers 30+ medical specialties as well as sections for nurses, medical students and pharmacists
- Over 150 Resource Centers
- Provides updates, continuing medical education (CME), conference schedules, Medline, drug searches and multiple specialty articles and an eclectic selection of journal abstracts
- Weekly newsletters and updates (MedPulse) and Best Evidence; both are features unique to Medscape
- Drug and Device Digest providing the latest in alerts and approvals; helpful for patient safety concerns
- A free personal web site option
- Dermatology atlas
- Clinical practice guidelines and Cochrane connection
- Sponsored by advertising[34]

MerckMedicus

- Multipurpose site sponsored by Merck and Company, customizable for 20 specialties
- 60+ specialty textbooks
- 150+ full text journals
- Cochrane Reviews links
- Clinical podcasts
- Includes customized versions of MDConsult and OVID, DxPlain (differential diagnosis engine from Harvard), medical news and national meeting reports
- PDR Electronic Library
- Patient handouts
- Unique 3-D Atlas of the human body

- Professional development using CME, board reviews, medical meetings, medical school links and Braunwald's Atlas of Internal Medicine (1500 slides you can copy). Also, a slide image bank of other slides that can be copied
- PDA portal, formatted for use with Palm or Pocket PC, includes news, the Merck Manual, Pocket Guide to Diagnostic Tests, and TheraDoc antibiotic assistant for PDA
- Journal abstracts and the ability to do a Medline search (If your PDA is not connected to wireless Internet, searches will be done the next time you synchronize with your PC.)
- State health professional license required for full access[35]

Amedeo

- This service will search major medical journals for a topic you select and then e-mail the results to you every week. It offers weekly webpage alerts displaying abstracts of selected journal tables of contents linked to PubMed.
- Covers about 100 topics falling into 25 specialties
- Valuable if you are a subject expert and don't have the time to do a frequent journal search on your own
- Related websites include Free Books 4 Doctors www.freebooks4doctors.com and Free Medical Journals www.freejournals4doctors.com
- Self-supported non-profit site [36]
- Similar tracking of articles also available through Google Alerts and NCBI (PubMed)

Resources Available in Sponsored and Non-Sponsored Versions

E-medicine

- 6,000 articles by 10,000 authors covering primary care and multiple sub-specialties
- Owned by WebMD and incorporated into Medscape
- Continually updated and peer reviewed Clinical Knowledge Base.
- Articles are referenced and selectively cross-referenced.
- References are presented at the end of each article with links to PubMed, but no footnotes in the text body.
- Levels of evidence not given
- CME available
- Institutional version, available at (http://www.imedicine.com offers PDA downloads, an extensive image library and monographs in pdf)
- Sponsored version and subscription versions available[37]

Online Epocrates

- Online Epocrates was the obvious next step after the successful PDA software program (see chapter on mobile technology)

- Both a free and fee based online version ($99 yearly) is offered
- Program covers 3300 drugs and 400 alternative medications
- Fee-based program includes local formulary information, pill identifier, MEDCALC 3000, alternative medications as well as an extensive drug library to augment Epocrates
- Free online program includes pill pictures and patient education
- Epocrates Linx is an online version that can integrate with an EHR
- The features online Epocrates offers over the PDA version: Ability to print or e-mail results, Medline search capability, pill pictures, MedCalc 3000 calculations and patient education sheets in English and Spanish
- Sponsored version and subscription versions available[38]

Government Medical Web Sites

National Library of Medicine

- **PubMed** (discussed in detail in chapter on search engines)
  - Provides free access to MEDLINE, NLM's database of citations and abstracts in the fields of medicine, nursing, dentistry, veterinary medicine, health care systems, and preclinical sciences.
  - Links to many sites providing full text articles and other related resources.
  - Provides a Clinical Queries search filters page as well as a Special Queries page.
  - Links to related articles for a selected citation.[39]
- **NLM Gateway**
  - Provide "one-stop shopping" for many of NLM's information resources
  - Offer citations, full text, video, audio, and images
  - Link within and across NLM databases[40]
- **Toxnet**
  - Cluster of databases covering toxicology, hazardous chemicals, environmental health and related areas[41]

National Guidelines Clearinghouse

- Comprehensive searchable database of evidence-based clinical practice guidelines and related documents
- Structured abstracts (summaries) about the guideline and its development
- Links to full-text guidelines, where available, and/or ordering information for print copies
- Palm-based PDA downloads of the complete NGC Summary for all guidelines
- Guideline comparison utility for a side to side comparison of multiple guidelines[42]

MedlinePlus

- Premier online patient education site
- Important to have in exam room

- Service of the National Library of Medicine and the National Institute of Health (NIH)
- Covers over 750 Health Topics in English and Spanish
- Drugs, Supplements, and Herbal Information
- Medical dictionary, encyclopedia and news
- 165 interactive video tutorials and surgical procedure videos
- Links to major patient education sites offered by health clinics, government and advocacy organizations such as, Mayo Clinic, National Institute of Health (NIH), American Heart Association, etc
- Links to Clinical Trials.gov to search research centers for specific diseases[43]

Other Excellent Free Patient Education Sites

- http://www.familydoctor.org/
- http://www.mayoclinic.com
- http://www.webmd.com
- http://kidshealth.org/

Free Medical Web Sites

HighWire Press

- Free site created by Stanford University to produce online peer-reviewed journals and scholarly content as open access or pay per view depending on the title
- Hosts 1270 journals with over four million full text and 2 million free full text articles
- Capability to search HighWire and Medline at same time with access to both free and pay-for-view articles
- E-mail alerts, PDA channels and RSS feeds available
- Site hosts 37 free trials of journals, 43 free journals, 249 journals that offer back issues free and approximately 1000 pay-for-view journals[44]

Medical Algorithms

- Developed by the Institute for Algorithmic Medicine, a n**on**-profit organization that develops online medical algorithms
- Currently includes 13,500 scales, tools and assessments
- Algorithms are evidenced-based with multiple references
- Many algorithms are presented as an Excel spreadsheet so you can plug in actual patient numbers and get immediate results
- Covers many unusual calculations not found in MedCalc and other similar programs[45]

Medical Podcasts

- Several medical organizations offer podcasts as a new form of medical education; usually in only an audio format and some in video

- The American College of Cardiology posts "*Heart Sounds*" in a MP3 format as a download
- The Arizona Heart Institute and Hospital provides podcasts as part of the Cardiovascular Multimedia Information Network
- The Journal of the American Medical Association, New England Journal of Medicine and other journals now offer audio article summaries as podcasts[46]

Subscription (fee based) Resources

MicroMedex

- MicroMedex offers multiple databases searchable with a single query
- New interface organizes the database into a point-of care tool
- Databases include Toxicology = POISONDEX, Disease = DISEADEX, Lab = Lab Advisor, Drug interactions = DRUGDEX , Human Reproductive Toxicology = REPRORISK, patient education handouts in English and Spanish = CareNotes
- Fully referenced drug database
- Available as web based and PDA (Palm, PocketPC and BlackBerry) based product
- Unlike Epocrates it has:
    - Both renal and liver failure dosing
    - Drug-food interactions
    - Off label uses
    - Comparative efficacy
    - IV Compatibility
    - Toxicology
    - References[47]

OVID

- Several hundred textbooks in most specialties including drug references
- Approximately two thousand full text medical journals
- Access is to journal articles is available by institutional subscription or pay per view
- Search interface supports natural language and Boolean searching
- Medline search capability linked to online full-text of journal articles
- Cochrane Library is available under the title Evidence-based Medicine Reviews
- Supports searching multiple databases simultaneously, i.e., Cochrane and Medline[48]

UpToDate

- Comprehensive resource containing over 80,000 pages of original, peer-reviewed text embedded with graphics and links to Medline abstracts
- Available online, on CD-ROMs or downloadable to PDA with personal subscriptions
- Individual, educational and institutional subscriptions available
- Personal subscribers receive CME researching clinical questions
- Institutional subscribers may purchase online or single workstation CD-ROMs; 60 day free trial to institutions
- Emphasizes Internal Medicine, Women's Health and Pediatrics
- Logically organized for fast answers
- 4,000 authors review 430 journals

- Began grading recommendations for treatment and screening in 2006 and is continuing to expand that effort
- Continuously updated with about 40% of the content being edited each quarter
- Drug database includes drug-drug interactions
- Patient information topics in English
- Available for download to smartphones, Pocket PC or Palm
- Emergency Medicine, Neurology and Allergy/Immunology in development
- Integrated into GE Centricity EHR[49]

MDConsult

- 60+ textbooks
- Over 50 full text journals
- 35 Clinics of North America
- Comprehensive drug database
- 1000 clinical practice guidelines
- 2500 Patient education handouts
- 50,000 medical images
- Online CME and medical news
- Medline search capability
- MDC Mobile is the PDA portal
- Excellent Search engine for entire site
- Individual and institutional subscriptions available[50]

StatRef

- Offers about 200 textbooks and Medline online in a cross-searchable reference tool that includes textbooks and evidence-based resources.
- ACP PIER, Journal Club & AHFS DI® Essentials™
- MedCalc3000
- PDA portal will allow downloads of ACP PIER content only
- Institutional subscriptions available[51]

Essential Evidence Plus (formerly InfoRetriever/Infopoems) is a program that was created by physicians for physicians. POEMS are "patient oriented evidence that matters". Specifically, this means the authors look for articles that are highly pertinent to patient care and patient outcomes.

- Consists of two products: DailyPOEMS and InfoRetriever
- DailyPOEMs are e-mailed to the subscriber M-F and are distilled from 100+ journals with only 1/40 accepted
- Site has 2000 POEMS
- POEM of the Week podcasts (RSS feeds available)
- Essential Evidence Plus (formerly InfoRetriever) available in online or handheld versions searches multiple resources simultaneously
- Essential Evidence Plus tools: EBM guidelines (1,000 primary care practice guidelines, 3000 evidence summaries and 1,000 photographs and images), Daily POEMS, Cochrane abstracts (2,193), Selected practice guidelines (751), Clinical decision rules (231)
- Number Needed to Treat (NNT) tool
- Derm Expert (photographic atlas)

- Diagnosis calculators (1180)
- History and physical exam calculators (1282)
- 5 Minute Clinical Consultant
- ICD-9 and E&M lookup tool
- Drug of Choice tool
- Searching results in a summary of resources on that topic categorized into typical quick reference categories like diagnosis, treatment, prognosis, etc. 5 Minute Clinical Consult monographs are listed first
- Available for desktop, Palm or Pocket PC
- Individual and institutional subscriptions available[52]

ACP Medicine

- Publication of the American College of Physicians and Web MD
- Previously known as *Scientific American Medicine*
- Evidence-based and peer-reviewed
- Covers most subspecialties plus Psychiatry, Women's Health, Dermatology and Interdisciplinary medicine
- Available in binder, CD-ROMs and Online
- Up to 120 hours CME available
- Binder version is 2800 pages
- Articles are dated and references are footnoted with PubMed links to the abstract
- Monthly updates (free) to be added to chapters P
- Handheld point-of-care tool, *Best DX/Best Rx*
- Individual and institutional subscriptions available[53]

ACP PIER

- Organized into five topic types: diseases, screening and prevention, complementary and alternative medicine, ethical and legal issues and procedures
- Each of the 430 disease modules presents guidance statements and practice recommendations, supported by evidence of evidence
- PDA version available
- Drug resource, accessible from every module page
- Provides the medical resource content for Allscript's EHR
- What they cover they do well.
- Like an online textbook; updated frequently
- Disease modules continue to be added P
- Available directly from the ACP and through StatRef by individual or institutional subscription[54]

FirstConsult

- Synthesizes evidence from journals and other sources into one database
- Offers concise, readable summaries of evidence that relate to patient care
- Organized into medical topics, differential diagnoses and procedures
- Updated weekly; major releases quarterly
- 475 topics at this point
- 300 Patient education files in English and Spanish

- Procedure files and videos
- EHR ready
- PDA Portal
- Handheld option, but the full library of topics it requires 10MB memory
- 30 day free trial
- Lack of a drug database and limited topics are negatives
- Individual and institutional subscriptions available[55]

DynaMed

- Disease and condition reference
- Almost 3000 clinical topics commonly seen in primary care
- Peer-reviewed and continually updated.
- Information presented based on validity, relevance and convenience
- All topics are organized in the same categories such as, general information, causes and risk factors, complications and associated conditions, history, physical, diagnosis, prognosis and treatment
- Bottom line recommendations are presented first, along with level of evidence. Links to articles will take you to the full text article if available and free online. Other links take you to PUBMED where some are linked through medical libraries to full text articles
- Weekly e-mail of important articles; also available as podcast
- PDA version free with subscription
- Can be linked to an EHR with the EBSCOhost Integration Toolkit
- Individual and institutional subscriptions available[56]

Table 7.1 is a matrix that compares many of the features of the online resources just covered. The speed of retrieval is an approximate estimate of how much time it takes to find an answer to a common medical question.

Table 7.1. Online resource comparison matrix. Speed (Slow =1, Fast = 4)

Source	Medline	CME	Books	Journals	Drugs	Newsletters Updates (e-mail)	Expert Opinion	Patient Info	Speed (1-4)
Medscape	X	X	X	X	X	X	X	X	3
MerckMedicus	X	X	X	X	X		X	X	3
OVID	X		X	X					2
UpToDate		X			X		X	X	4
MDConsult	X	X	X	X	X		X	X	2
FirstConsult							X	X	4
StatRef	X		X						2
ACP Medicine		X				Updates to site only	X		3
eMedicine	X	X	X	X	X		X	X	3
DynaMed					X	X	X	X	4

Key Points

- Paper based libraries are quickly becoming virtual
- Online libraries offer much faster retrieval of articles
- Online libraries are easier to update
- There is now a broad range of online services for all specialties that includes both free and fee based services

Conclusion

Online resources are becoming the medical library of choice for healthcare workers due to depth of content and speed of retrieval. Furthermore, subject matter can be updated more rapidly compared to standard textbooks. Many excellent resources are free and the subscription resources are competitive with traditional textbooks. Resources vary from a low of about 400 topics to a high of 8000 topics. Prices tend to correlate with the scope of the content offered. There are many free resources that should be considered by all clinicians such as Epocrates Online, MedlinePlus and Medscape. The authors want to stress that very extensive resources such as UpToDate, eMedicine and DynaMed offer the greatest possibility of finding an answer in a few clicks. Other resources may point you to multiple book chapters and journal articles where you must sift through the data to find the answer. Clinicians are strongly encouraged to "test drive" these resources, adopt the ones that make the most sense and add them as desktop icons in each exam room.

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8

Search Engines

JANE PELLIGRINO
ROBERT HOYT

Learning Objectives

After reading this chapter the reader should be able to:

- State the significance of rapid high quality medical searches
- Define the role of Google in healthcare and its many search features
- Describe the meta-search engines and the features that are distinct from Google
- Describe the role of PubMed and Medline searches
- Identify the variety of search filters essential to an excellent PubMed search
- Enhance PubMed searching with third party PubMed tools
- Use NLM Mobile

"Getting information off the Internet is like taking a drink from a fire hydrant"
Mitchell Kapor

The most rapid and comprehensive way to access information today from anywhere in the world is a search of the World Wide Web via the Internet. If we assume that the Internet is the new global library with more than 3 billion web sites, then it should come as no surprise that search engines are the gateway. Popular search engines such as Google provide successful searches for medical and non-medical issues. Although PubMed is the search engine of choice for formal searches of the medical literature, most inquiries are informal so searches need to yield primarily rapid and relevant results. Given the prevalence of web surfing for answers, multiple articles have been written about "*search wars*".[1-2] It is unclear to what extent the use of search engines has changed human behavior and medical knowledge in the past fifteen years. Previously, questions such as "*what is the difference between HDL and LDL cholesterol*" meant a trip to the library, the purchase of a book or a visit with a doctor. Now anyone can execute a search and have a reasonable likelihood that the search will be successful.

Just as important as selecting the search engine with which you are comfortable is learning to use all of the advanced search options. It is imperative to use filters to refine a search or you will become frustrated by the avalanche of information returned. In this chapter we will begin with a discussion of Google, followed by other less well-known search engines and finally a primer on PubMed searching.

Google

Google is by far the most widely used search engine in the world.[3] Its name is derived from the word googol which is the mathematical term for the number 1 followed by 100 zeroes.[4] Google's success is based largely on its intuitiveness, retrieval speed and productive results. Google is listed as one of the ten forces to flatten the world in Thomas Friedman's book "*The World is Flat*".[5] Google has proven to be a fascinating company with a myriad of innovations on a regular basis.

Google was developed by Larry Page and Sergey Brin in 1996 when they were graduate students at Stanford. They created the "backrub" strategy which meant that a search would prioritize the results by ranking the page that is linked the most first (page ranking).[6] Some could argue that it used a popularity contest as a strategy. A shortcoming of this approach would be that new web sites might take time to be linked. As the world's largest and fastest search engine it performs one billion searches daily by utilizing thousands of servers (server farm) running the Linux operating system.[7] "*Googling*" has deeply influenced the users' expectations about the answers to their questions and the way of searching the web.[8] Google can be criticized for being a shotgun and not a rifle in terms of returning too many results but this has not diminished its popularity. Because Google yields so many results in an average search, it is very important to learn about how to narrow or filter a search.

Google can be an acceptable medical search engine for common as well as rare conditions that are not likely to be found in journals or textbooks. Google provides a very global review, returning articles from the lay press, medical journals, magazines, etc. In a 2006 article, Dr. Robert Steinbrook notes that Google (56%) was the most common search engine used to refer someone to find a medical article at High Wire Press; compared to PubMed (8.7%).[9]

Google will cite Medline abstracts and occasionally full text articles, so for an informal search it is not unreasonable to start with Google to see if you find an answer in the first few citations listed. It is likely you will find an acceptable answer in less time than it takes to use PubMed, particularly if you narrow the search with additional descriptors and use an advanced search strategy. Meats et al[10] showed that clinicians searching for medical information prefer to use a simple strategy of the disease term and the population in question. Google makes that type of searching possible albeit inefficient if advanced search techniques are not employed. If you search with the terms *type 2 diabetes foot checks frequency* you will likely retrieve clinical articles that describe how often foot checks should be performed in diabetics. In a Google search the most important term should be listed first.

Several recent articles in the medical literature have confirmed that Google has become a common medical search engine; even at academic centers.[11-13] Google continued its foray into the medical world in 2008 by launching Google Health. Google is very aware that many patients use Google to search for medical answers to common and complex health questions.[14] Google developed Google Health in response to the fact that 25% of the Internet searches are health related and that there is growing desire for universally available online medical records. Google Health allows users to upload, store and manage personal health information in one place at no cost. Although privacy advocates have voiced security concerns, Google states that it will never sell the information and that the information is secure and private. Successful searching depends on maximizing Google search options.

- Begin by setting preferences
    - Language you prefer e.g. English
    - Number of search results per page e.g. 10 or 20
    - Whether you want your search to launch in new window (Recommended: When you exit the current page, you lose your search.)
- Select the ***Advanced search*** option on the main page
    - Under occurrences (Find webpages that have..) you can search for a term in the title only or in the body or both
    - Search for synonyms using OR as the operator
    - Select search by domain such as .org, .edu or .gov
    - Select search by format: Word, Excel, PDF, PowerPoint, etc

  - Put quotation marks around the words to search for an exact phrase, e.g. "University of West Florida" so you don't retrieve every citation with the words Florida, West or University

- Take a look at ***Advanced operators*** to refine the search
  - Type *define*:, *phone*book: or *bphonebook*: before a word or phrase to have Google serve as a dictionary, white pages or yellow pages, e.g., *define*: colon or *phone*book: Mark Evans, *bphonebook*: Walmart
  - Enter an arithmetic string and Google will function as a calculator
- **Essentials of a Google Search** (www.google.com/help/basics.html) Provides helpful tips to improve the search process:
  - Searches are not case sensitive
  - The word "and" is not necessary, because Google, unlike PubMed, "and" is implied. Use Advanced search to use "or"
  - Most popular web sites are listed first
  - For a search of a common subject, select "I'm feeling lucky" on the main Google search page and you will be taken to the most popular web sites on the subject[15]

The following are Google features that, in our judgment are relevant to Medical Informatics:

- Google includes an ***Image*** search of over 880 million images (some copyrighted). Advanced image search filters are available
- ***Google Talk*** is voice over Internet protocol (IP). You can talk to another person via your computer and the Internet
- ***Gmail*** is free web mail. Unlike other web mail services it offers over 2 gigabytes of memory. Google maintains that you don't need to organize your e-mail into folders because of its excellent search engine
- ***Google Docs & Spreadsheets*** provides an alternative to Microsoft Word and Excel. You can collaborate with others and publish your work to a web site. Only drawback is a limit of 500 K for a document upload
- ***Google Groups*** creates a collaborative web site where you can post discussions and web content. Members can be by invitation only
- ***Google Directory*** organizes the Web into categories so the search may be more focused. If you search, for example, under a Health directory > Medicine > Informatics > Telemedicine, the search will yield page ranked web sites so you do not see citations from the lay press, PubMed, etc. The web site choices are actually selected by experts so this is why the number of sites returned is far smaller than a true web search
- ***Google Health*** is a personal health record system for consumers[16]
- ***Google Health Topics***[17] provides extensive references on health topics including overview, treatment, diagnosis, clinical guidelines, symptoms, complications, news and more
- ***Google Custom Search Engines*** under "co-op" you will find the ability to customize searches by limiting them to certain web sites. You can also integrate this search engine into your personal web site
- ***Google Code*** searches for open source codes and APIs (application programming interface

- ***Google Page Creator*** creates simple web pages with easy to use tools so anyone can create their own web site
- ***Google Scholar*** (feature is described below) uses the Google search engine to search journal articles at publishers' websites
- ***Google Desktop search*** program rapidly searches your personal computer files. Tends to be much faster than the Microsoft search function located in the start menu
- ***Book Search (beta)*** provides access to books online in the public domain. Potentially Google Books will search 50 million textbooks. If a book is currently copyrighted, there will be a link to purchase the book or borrow it from a library[18]
- Google changes so rapidly it is a good idea to look at ***Google labs*** often. It provides new web page alerts and news alerts, toolbar shortcuts, a glossary and discussion groups and the ability to create a web page. Alerts can track any topic and e-mail you any new information as it becomes available

Google Scholar

Google ***Scholar*** is an offspring of Google that searches the full text of peer-reviewed scholarly journal articles at publishers' websites and the citations and abstracts provided online by the National Library of Medicine through PubMed.[19-20] Google Scholar uses the same search technology as its parent. Because the search technology relies on an algorithm that weighs articles by their links to other relevant content, it is difficult to retrieve recent articles. Google Scholar delivers the quantity of retrieval, but not the quality necessary to allow it to standalone. Because Google Scholar searches the full text of articles in contrast to PubMed that searches the title and abstract, Google Scholar enables the searcher to retrieve articles that contain words and phrases not found in the title or abstract. Google Scholar makes searching easier, but it should be used in conjunction with PubMed, not as a replacement for it. Google Scholar offers "cited by referencing" which is not available elsewhere for free.[21] Google Scholar is a good tool for accessing the open source literature, it provides access to unique content not in other search tools and it is free and openly available.[22]

Other Search Engines

Meta-search engines search more than one database or utilize more than one search engine.[22-25] It remains to be seen if this is necessarily an advantage or not. We could find no publications or reviews regarding their use in medical searches.

Bing

- Search engine introduced by Microsoft in May, 2009 as a challenger to Google
- Intuitive search box with enhanced search capability
- Bing targets four most important categories of search: shopping, travel, health and local with specialized results displays for each category
- Displays results in search categories on a left hand navigation bar
- Displays search history[26]

Clusty, powered by Vivisimo

- Metasearch engine that searches the web, images, Wikipedia, blogs, government, etc

- Available for mobile devices and as a Firefox Mozilla add-on for desktop searches
- "Clusters" the search into sub-topics in convenient folders
- Vivisimo now offers a *Velocity* option that is more specific for the life sciences and bioinformatics
- Powers USAgov.gov
- Adopted by the National Library of Medicine and MedlinePlus to use on their web sites[27]

Dogpile

- Metasearch engine that searches Google, MSN, Ask Jeeves and Yahoo
- Advanced search uses the filters of qualified words or phrases, language, dates and domain; similar to Google
- Searches sponsored and non-sponsored web sites
- Search the web, images, audio, video, news, white and yellow pages
- Note: a 2008 search for avian influenza returned 69 high quality citations, whereas a Google search returned 2.3 million![28]

Omni Medical Search

- Although touted as a medical meta-search engine, it does not utilize different search engines and has very limited filters
- Tabs conduct searches of the web, news, images, forums and MedPro
- MedPro search is intended for serious medical inquiries, yet yielded very limited results and is associated with commercial influence. They now use Google as their search engine as well as ads by Google
- Available as a desktop toolbar search engine
- A reference desk includes searches for medical: acronyms, dictionaries, images, associations, databases, journals, conditions and diseases and forums[29]

PubMed Search Engine

PubMed[30] is a web-based retrieval system developed by the National Center for Biotechnology Information (NCBI) at the National Library of Medicine (NLM). PubMed is one of twenty-three databases in NCBI's retrieval system, known as *Entrez*. *Entrez* includes biological databases that index information in toxicology, bioinformatics and genomics and even includes textbooks.

MEDLINE is the primary *Entrez* database, containing 19 million citations from the world's medical literature from the 1940s to the present, covering the fields of medicine, nursing, dentistry, veterinary medicine, health care administration, the pre-clinical sciences and some other areas of the life sciences.[31] NLM licenses its data to vendors to be used through proprietary interfaces, but PubMed search interface for MEDLINE is only available directly from the National Library of Medicine.

For simple answers to common problems PubMed may not be the place to begin a search, but it is the primary search engine for physicians seeking information on unusual cases and research topics. Although some would argue that the PubMed search process is too labor-intensive, all physicians seeking to retrieve evidence-based medical answers should learn to use PubMed. It is especially important in an academic or research environment. Without proper training PubMed searching can be challenging and frustrating. This section emphasizes the important features and shortcuts to make a search easier and more successful. Excellent tutorials exist on the PubMed site

to teach you the basics of a good search. Also, several helpful review articles have been written that address PubMed tools and features.[32-34]

The query box in PubMed (Fig. 8.1) allows keyword, Medical Subject Headings (MeSH) and natural language (Google-type) entries. Search terms may be entered alone or connected by search operators, such as "AND" or "OR". The goal of the search is to find specific citations on the topic described by the search terms.

Figure 8.1 PubMed homepage[35]

PubMed citations include the author, title, journal, publication date and PubMed identification number (PMID) as shown in Fig. 8.2 and 65% of the citations include an author abstract. PubMed does not search the full-text of cited articles.

Zerboni L, Sommer M, Ware CF, Arvin AM.
Varicella-zoster virus infection of a human CD4-positive T-cell line.
Virology. 2000 May 10;270(2):278-85.
PMID 10792986 [PubMed - indexed for MEDLINE]

Figure 8.2 Medline citation (courtesy National Library of Medicine)

Medical Subject Heading (MeSH). Journal articles are categorized by NLM indexers in order to facilitate searching. Articles are saved under one or more subject headings using a structured vocabulary called MeSH. Understanding what these terms are and how they can refine a search is an important first step in harnessing the power of PubMed. As you can imagine, terms such as low back pain could be labeled lumbar pain, osteoarthritis of the lumbar spine, etc. It will improve your search significantly, if you search with the preferred term, so take a moment to look at MeSH. You can access MeSH in the drop down menu in the search window or by choosing the MeSH Database in the menu on the left.

Figure 8.3 shows how low back pain is organized in MeSH. The MeSH entry shows a definition of the term and its synonyms and displays a set of subheadings with which to narrow a search on low back pain. You can even restrict your search to the term as a "Major Topic."

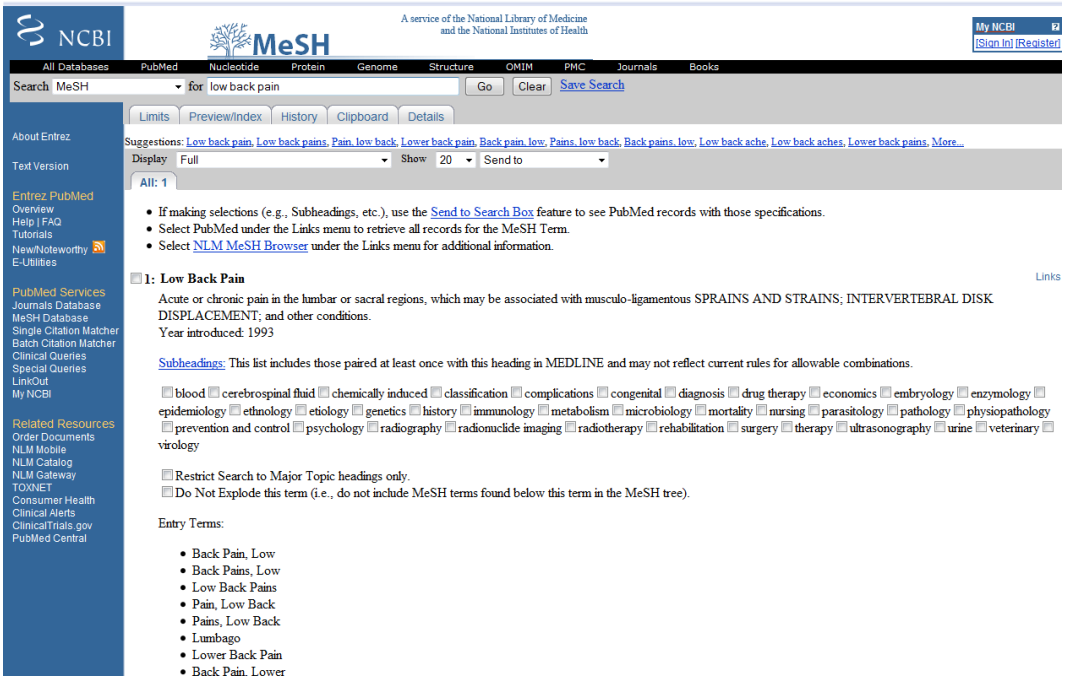

NCBI
MeSH
A service of the National Library of Medicine and the National Institutes of Health
My NCBI
[Sign In] [Register]
All Databases PubMed Nucleotide Protein Genome Structure OMIM PMC Journals Books
Search MeSH for low back pain Go Clear Save Search
Limits Preview/Index History Clipboard Details
About Entrez
Text Version
Entrez PubMed
Overview
Help | FAQ
Tutorials
New/Noteworthy
E-Utilities
PubMed Services
Journals Database
MeSH Database
Single Citation Matcher
Batch Citation Matcher
Clinical Queries
Special Queries
LinkOut
My NCBI
Related Resources
Order Documents
NLM Mobile
NLM Catalog
NLM Gateway
TOXNET
Consumer Health
Clinical Alerts
ClinicalTrials.gov
PubMed Central
Suggestions: Low back pain, Low back pains, Pain, low back, Lower back pain, Back pain, low, Pains, low back, Back pains, low, Low back ache, Low back aches, Lower back pains, More...
Display Full Show 20 Send to
All: 1
If making selections (e.g., Subheadings, etc.), use the Send to Search Box feature to see PubMed records with those specifications.
Select PubMed under the Links menu to retrieve all records for the MeSH Term.
Select NLM MeSH Browser under the Links menu for additional information.
1: Low Back Pain
Links
Acute or chronic pain in the lumbar or sacral regions, which may be associated with musculo-ligamentous SPRAINS AND STRAINS; INTERVERTEBRAL DISK DISPLACEMENT; and other conditions.
Year introduced: 1993
Subheadings: This list includes those paired at least once with this heading in MEDLINE and may not reflect current rules for allowable combinations.
blood cerebrospinal fluid chemically induced classification complications congenital diagnosis drug therapy economics embryology enzymology epidemiology ethnology etiology genetics history immunology metabolism microbiology mortality nursing parasitology pathology physiopathology prevention and control psychology radiography radionuclide imaging radiotherapy rehabilitation surgery therapy ultrasonography urine veterinary virology
Restrict Search to Major Topic headings only.
Do Not Explode this term (i.e., do not include MeSH terms found below this term in the MeSH tree).
Entry Terms:
Back Pain, Low
Back Pains, Low
Low Back Pains
Pain, Low Back
Pains, Low Back
Lumbago
Lower Back Pain
Back Pain, Lower

Figure 8.3 MESH term display (courtesy National Library of Medicine)

Figure 8.4 illustrates a search for sinusitis in MeSH. Different types of sinusitis are listed. Under each term "entry terms" are provided as above (Fig. 8.3).

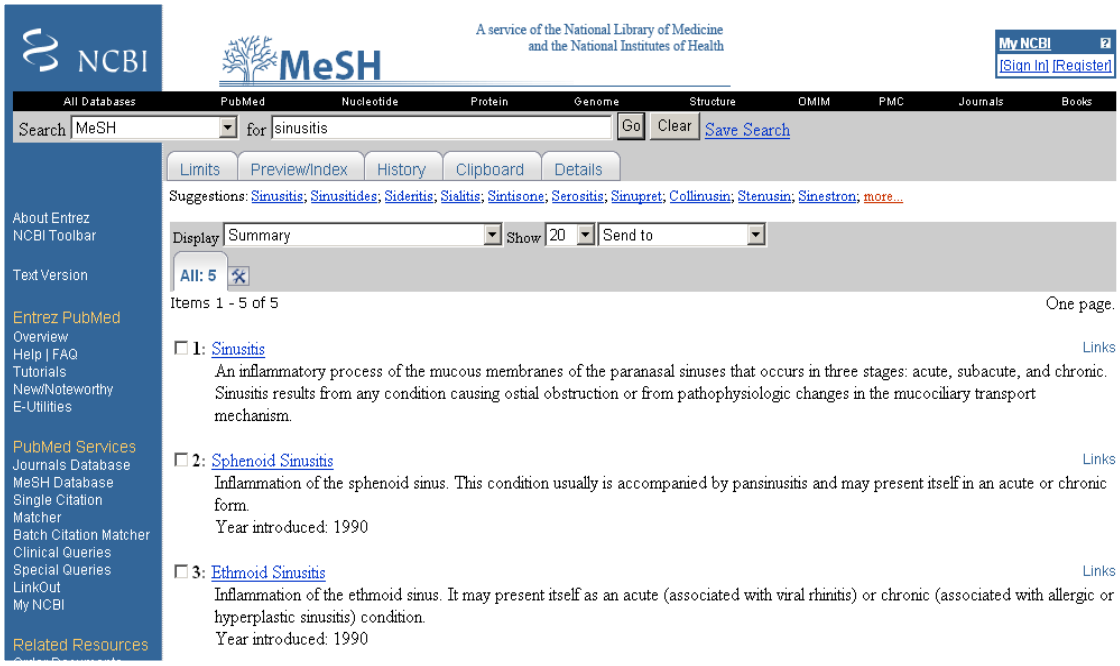

NCBI
MeSH
A service of the National Library of Medicine and the National Institutes of Health
My NCBI
[Sign In] [Register]
All Databases PubMed Nucleotide Protein Genome Structure OMIM PMC Journals Books
Search MeSH for sinusitis Go Clear Save Search
Limits Preview/Index History Clipboard Details
About Entrez
NCBI Toolbar
Text Version
Entrez PubMed
Overview
Help | FAQ
Tutorials
New/Noteworthy
E-Utilities
PubMed Services
Journals Database
MeSH Database
Single Citation Matcher
Batch Citation Matcher
Clinical Queries
Special Queries
LinkOut
My NCBI
Related Resources
Suggestions: Sinusitis; Sinusitides; Sideritis; Sialitis; Sintisone; Serositis; Sinupret; Collinusin; Stenusin; Sinestron; more...
Display Summary Show 20 Send to
All: 5
Items 1 - 5 of 5
One page.
1: Sinusitis
Links
An inflammatory process of the mucous membranes of the paranasal sinuses that occurs in three stages: acute, subacute, and chronic. Sinusitis results from any condition causing ostial obstruction or from pathophysiologic changes in the mucociliary transport mechanism.
2: Sphenoid Sinusitis
Links
Inflammation of the sphenoid sinus. This condition usually is accompanied by pansinusitis and may present itself in an acute or chronic form.
Year introduced: 1990
3: Ethmoid Sinusitis
Links
Inflammation of the ethmoid sinus. It may present itself as an acute (associated with viral rhinitis) or chronic (associated with allergic or hyperplastic sinusitis) condition.
Year introduced: 1990

Figure 8.4 MESH term search

At the bottom of each MeSH entry is the categorical display or "MeSH Tree" as shown in Fig. 8.5. Searching the term, sinusitis, includes all the specific types listed under it, broadening the search. Conversely, reviewing sinusitis in MeSH allows you to discover the specific type of sinusitis available so that you may search the one that fits your query the best. MeSH is valuable in broadening or narrowing a search query.

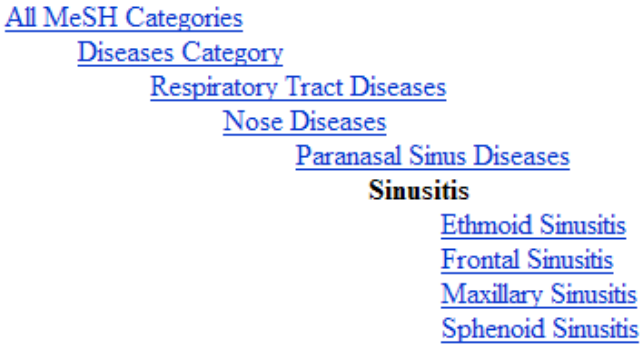


Figure 8.5 MeSH categories

If you are struggling with your search terms in PubMed and not finding what you need, you may want to check your search terms in MeSH to see if the term is accepted by PubMed. Searching with the correct term can make all the difference. As is the case with Google searching, learning to use filters such as MeSH will result in more successful retrieval of information.

PubMed Limits Option allows a search to be narrowed by date, age of subjects, gender, humans or animals, language, publication types, topics and field tags**.**

- You can also search for full text and free full text articles and abstracts. (Keep in mind that most articles before 1975 did not contain abstracts.)
- You can search by author or journal name
- Searchable main publication types:
    - Clinical Trial
    - Editorial
    - Letter
    - Meta-Analysis
    - Practice Guideline
    - Randomized Controlled Trial
    - Review
- Searchable topic subsets:
    - AIDS
    - Bioethics
    - Cancer
    - Complementary Medicine
    - History of Medicine
    - Space Life Sciences
    - Systematic Reviews
    - Toxicology

- Field tags. You can stipulate whether you want the search term in the title or body of the article. Multiple other choices are listed as well

Entering a search in PubMed

PubMed is based on a system architecture that uses indexed concepts (MeSH Headings) and Boolean logic to retrieve information. Search questions should be analyzed and broken down into concepts that are joined together by AND to retrieve articles that contain both concepts or joined together by OR to retrieve articles that contain either concept. To search for articles on sinusitis caused by bacteria search bacterial infections AND sinusitis.

Although the search box in PubMed looks very much like Google, the words entered in the search box are processed based on concept searching rather than natural language searching. Recognizing that most searchers are accustomed to searching in Google, PubMed is developing a natural language search engine.

Once the concept search has been entered you may limit the search with the search parameters. We are now going to search with the following limits for sinusitis: Field = title, Age = 19-44, humans, Core clinical journals (all of which are in English), added to PubMed in past 5 years and links to free full text. We could have also selected clinical trial, random controlled trial or review or checked the box for all four. At the right side of the screen are suggestions for broadening the search and the Recent Activity

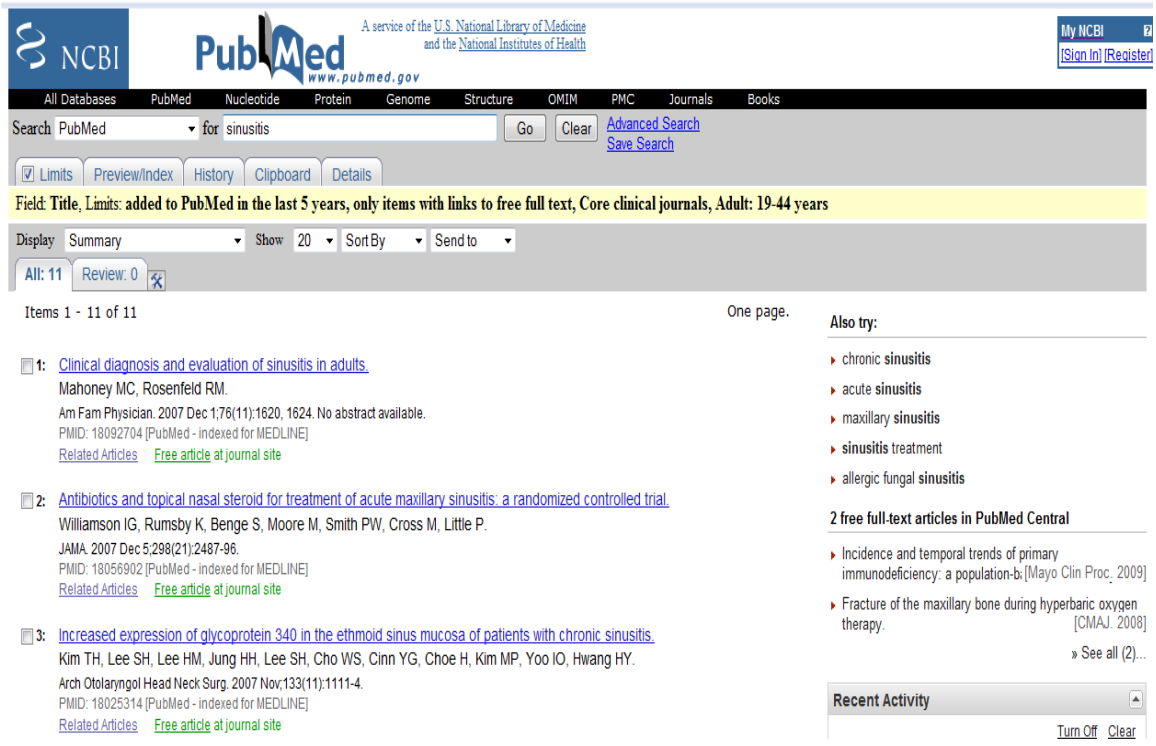
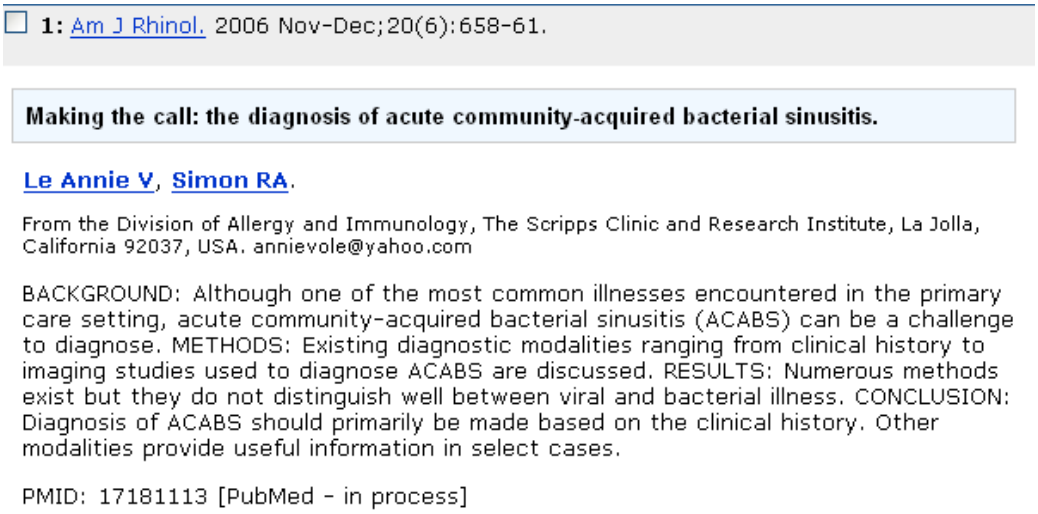

NCBI
PubMed
www.pubmed.gov
A service of the U.S. National Library of Medicine and the National Institutes of Health
My NCBI
[Sign In] [Register]
All Databases PubMed Nucleotide Protein Genome Structure OMIM PMC Journals Books
Search PubMed for sinusitis Go Clear Advanced Search Save Search
Limits Preview/Index History Clipboard Details
Field: Title, Limits: added to PubMed in the last 5 years, only items with links to free full text, Core clinical journals, Adult: 19-44 years
Display Summary Show 20 Sort By Send to
All: 11 Review: 0
Items 1 - 11 of 11
One page.
1: Clinical diagnosis and evaluation of sinusitis in adults.
Mahoney MC, Rosenfeld RM.
Am Fam Physician. 2007 Dec 1;76(11):1620, 1624. No abstract available.
PMID: 18092704 [PubMed - indexed for MEDLINE]
Related Articles Free article at journal site
2: Antibiotics and topical nasal steroid for treatment of acute maxillary sinusitis: a randomized controlled trial.
Williamson IG, Rumsby K, Benge S, Moore M, Smith PW, Cross M, Little P.
JAMA. 2007 Dec 5;298(21):2487-96.
PMID: 18056902 [PubMed - indexed for MEDLINE]
Related Articles Free article at journal site
3: Increased expression of glycoprotein 340 in the ethmoid sinus mucosa of patients with chronic sinusitis.
Kim TH, Lee SH, Lee HM, Jung HH, Lee SH, Cho WS, Cinn YG, Choe H, Kim MP, Yoo IO, Hwang HY.
Arch Otolaryngol Head Neck Surg. 2007 Nov;133(11):1111-4.
PMID: 18025314 [PubMed - indexed for MEDLINE]
Related Articles Free article at journal site
Also try:
chronic sinusitis
acute sinusitis
maxillary sinusitis
sinusitis treatment
allergic fungal sinusitis
2 free full-text articles in PubMed Central
Incidence and temporal trends of primary immunodeficiency: a population-b [Mayo Clin Proc. 2009]
Fracture of the maxillary bone during hyperbaric oxygen therapy. [CMAJ. 2008]
» See all (2)...
Recent Activity
Turn Off Clear

Figure 8.6 Search for sinusitis with multiple limits (courtesy National Library of Medicine)

Our search with limits has greatly reduced the number of returned citations and improved the quality (Fig. 8.6). Requesting free full text articles also reduces the search considerably. When we changed the search to any abstract, instead of free full text articles, 60 citations were returned.

- Note that the most current articles are listed first. Also notice that in spite of asking for articles only dealing with adults, a pediatric guideline returned. Perhaps this is because the guideline deals with patients ages 0-18
- Most articles today are associated with an abstract that summarizes the article (Fig.8.7)
- You **must go to the full text article for more detail**



1: Am J Rhinol. 2006 Nov-Dec;20(6):658-61.

Making the call: the diagnosis of acute community-acquired bacterial sinusitis.

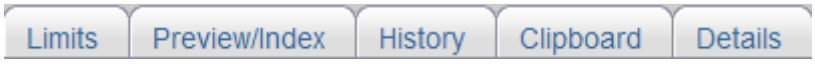
Le Annie V, Simon RA.

From the Division of Allergy and Immunology, The Scripps Clinic and Research Institute, La Jolla, California 92037, USA. annievole@yahoo.com

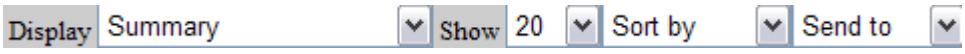
BACKGROUND: Although one of the most common illnesses encountered in the primary care setting, acute community-acquired bacterial sinusitis (ACABS) can be a challenge to diagnose. METHODS: Existing diagnostic modalities ranging from clinical history to imaging studies used to diagnose ACABS are discussed. RESULTS: Numerous methods exist but they do not distinguish well between viral and bacterial illness. CONCLUSION: Diagnosis of ACABS should primarily be made based on the clinical history. Other modalities provide useful information in select cases.

PMID: 17181113 [PubMed - in process]

Figure 8.7 Example of an abstract (courtesy National Library of Medicine)

- PubMed uses Boolean operators such as AND, OR and NOT and they must be capitalized. Instead of the search strategy used above we could have used the same limits but in the main search window used "sinusitis AND treatment" (no quotation marks necessary)
- Other tab options 

    - Preview/Index--preview the number of search results before displaying the citations. View your search strategy as you continue to refine your search
    - History--holds all of your searches for 8 hours. You can combine several searches by combining for example #2 and #3 searches
    - Clipboard--allows you store up to 500 citations for up to 8 hours
    - Details--summarizes how you performed your search
- More options



    - Display window--it automatically defaults to summary but you can also select abstract, Medline, XML and others
    - Show--you can elect to show between 5-500 citations per page
    - Sort by-- you can sort by author, journal or published date
    - Send to--your choices are e-mail, text, file, printer, clipboard, RSS feed or order article from a library using Loansome Doc

- Single Citation Matcher—located under the left main menu. There are times when you are trying to locate an article and you have an approximate idea as to who the author is or the year or the journal. You can search by author, journal, date, volume, issue, page or title words
- Clinical Queries—also located under the left main menu. Provides another way to search for articles reporting the results of randomized controlled trials with the use of built-in filters:
    - Research methodology filters developed at McMaster University that are built into the Clinical Queries interface, so you can search for randomized controlled trials by etiology (cause), diagnosis, therapy, prognosis or search for clinical prediction guides. Searches can be modified to be either broad/sensitive manner or narrow/specific
    - Systematic reviews—this type of review critically appraises multiple random controlled trials to give conclusions more strength (covered in more detail in the chapter on evidence based medicine). Topics can be narrowed to the subset of systematic reviews by using the Clinical Queries interface
- My NCBI—also located on upper right hand corner of the main screen. Provides a valuable storage area for searches and collections of articles you are retrieving allowing you to:
    - Save searches (otherwise gone in 8 hrs)
    - Set up e-mail alerts so you are notified when new articles are published on your topic of interest
    - Display links to online full-text of articles (LinkOut)
    - Choose filters that group search results
    - You must register for this free service
- Related articles and Links. To the right of each article you will see a hyperlink to similar or related articles. Select Links and it can link you to:
    - PubMed books
    - Links—if the article is free and full text, PubMed Central (www.pubmedcentral.nih.gov) may have it
    - Link Out—can take you to external resources such as OVID or MDConsult if you subscribe and set this up. May also take you to other sites such as MedlinePlus for patient education material
- PubMed PICO search, part of PubMed for Handhelds —aids in the construction of a well thought out question prior to initiating a search. This tool divides the question into sections defining the patient or problem, intervention, comparison and outcome (P.I.C.O). The URL or web address could be a desktop icon shortcut or a program on your handheld for fast searches [36]
    - (**P**) atient or problem—how do you describe the patient group you are interested in? Elderly? Gender?
    - (**I**) ntervention, prognostic factor or exposure-- Drug? Lab test? Tobacco?
    - (**C**) omparison—with another drug or placebo?
    - (**O**) utcome—what are you trying to measure? Mortality? Reduced heart attacks?
    - PubMed® for Handhelds website offers several search options for MEDLINE® with the web browser of any mobile device (Fig. 8.8) [37]

Figure 8.8 Example of PubMed® for Handhelds (Courtesy National Library of Medicine)

- PubMed Central—hosts multiple free full text articles. Unfortunately, many are located in minor journals of recent vintage. They are also more weighted towards a bioinformatics search

Third Party PubMed tools

The National Library of Medicine (NLM) makes its database of citations available to the public for searching, and it also makes its data available through an application programming interface (API). The API allows interested users to write programs that mine the MEDLINE database in new ways. Several applications designed to optimize MEDLINE searching are available and others are emerging continually in an effort to exploit the MEDLINE data and may be more accessible to the user. Below are some examples of these third party PubMed tools that are worthy of merit.[38]

PubMed PubReMiner MeSH searching gives power to a PubMed searching. PubReMiner allows the searcher to enter keywords related to a query and then analyzes the relevant PubMed citations and their indexing to develop a list of terms with which to expand the search. PubReMiner is available directly from the website or through a web browser plug-in that is available for Mozilla Firefox or Internet Explorer 7.0.[39]

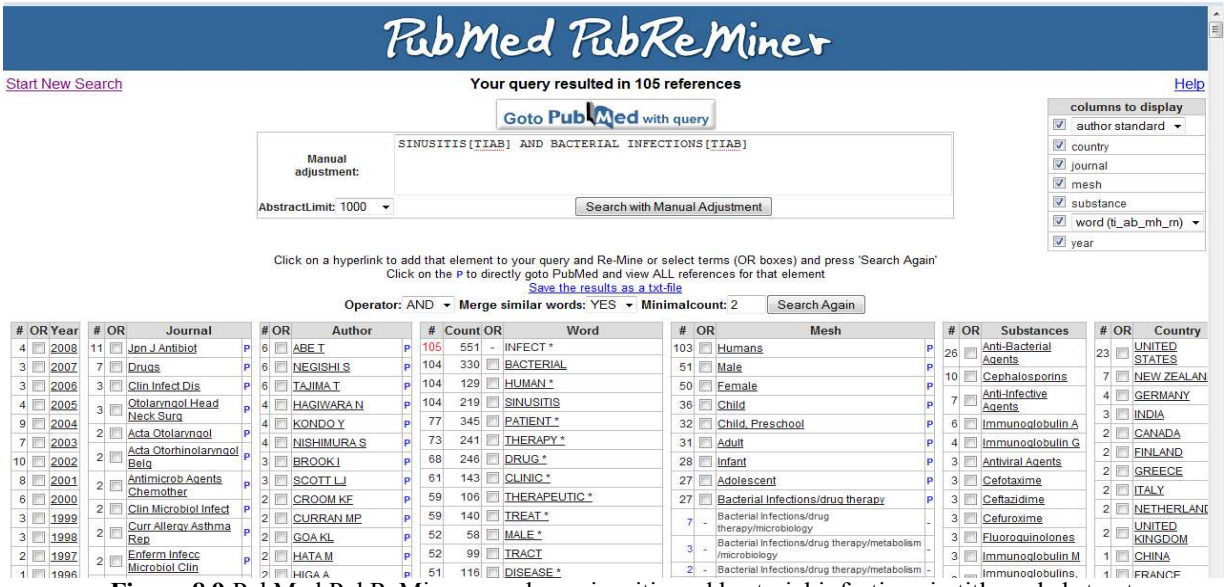


Figure 8.9 PubMed PubReMiner search on sinusitis and bacterial infections in title and abstract

PubFocus.[40] **PubFocus** performs statistical analysis of the MEDLINE/PubMed search queries enriched with the additional information gathered from journal rank database and forward referencing database. PubFocus analyzes PubMed output to identify foci of research activity.

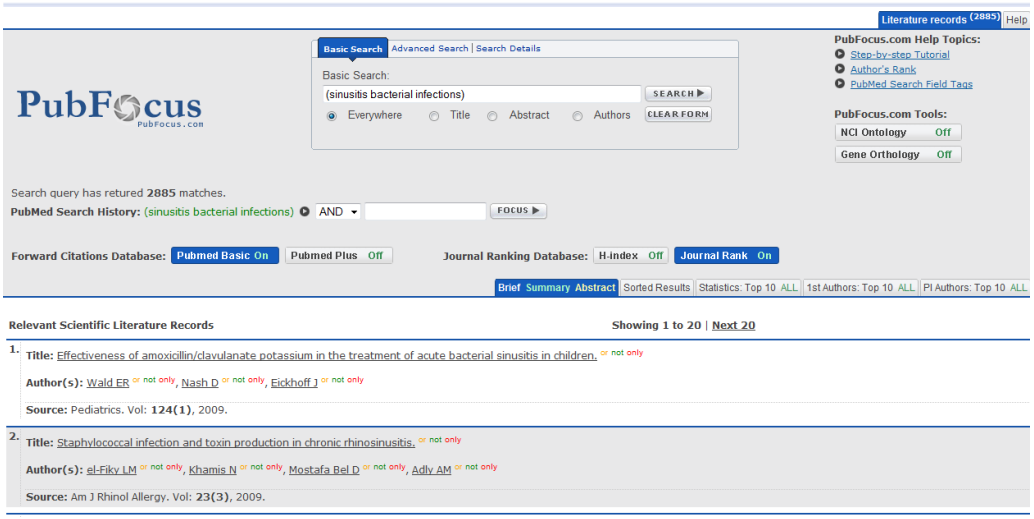


Figure 8.10 PubFocus Basic Search on sinusitis and bacterial infections

Novo|Seek Novo|seek indexes the medical literature with text mining tools that identify key biomedical terms. Novo|seek indexes the biomedical literature and US grants for over 75 institutions including the US National Institutes of Health (NIH), the National Science Foundation, US Department of Agriculture and the Centers for Disease Control and Prevention (CDCP) with a text mining technology that enables the identification of key terms. Novo|seek is able to retrieve every document where a term is mentioned regardless of synonym. Novo|seek extracts precise information, retrieves key biomedical concepts, filters results, reviews key information derived from thousands of documents, identifies key research concepts by author and links to relevant external chemical and biological information.[41]

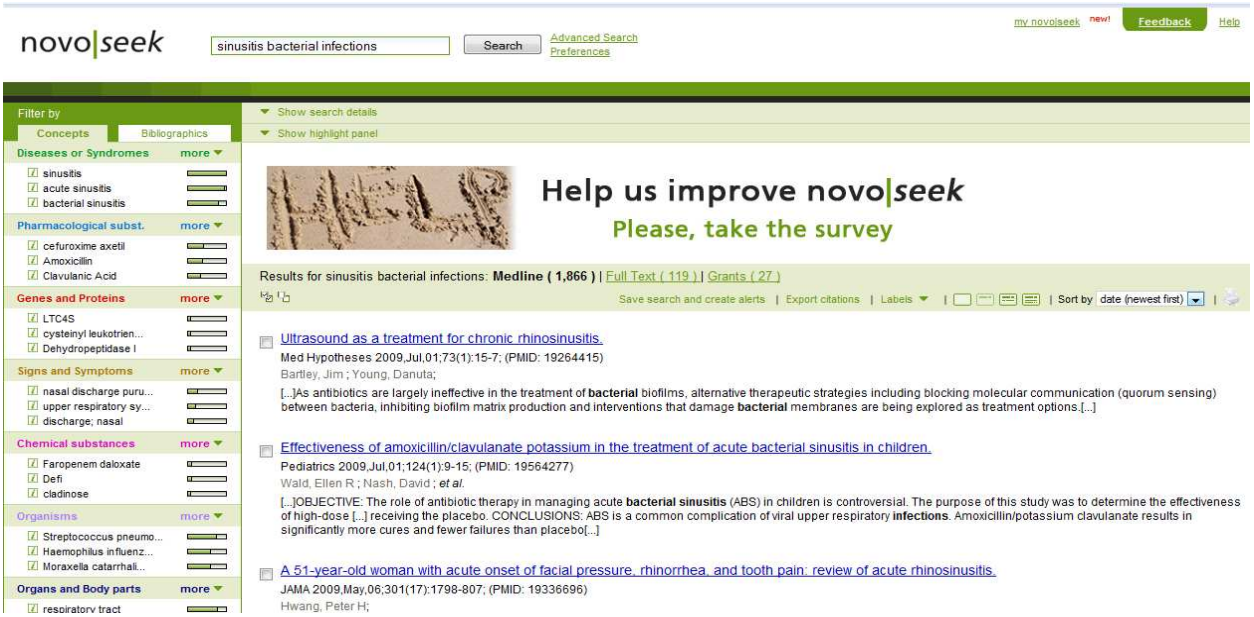

novo|seek
sinusitis bacterial infections
Search
Advanced Search
Preferences
my novo|seek
new!
Feedback
Help
Filter by
Concepts
Bibliographics
Show search details
Show highlight panel
Diseases or Syndromes more
sinusitis
acute sinusitis
bacterial sinusitis
Pharmacological subst. more
cefuroxime axetil
Amoxicillin
Clavulanic Acid
Genes and Proteins more
LTC4S
cysteinyl leukotrien...
Dehydropeptidase I
Signs and Symptoms more
nasal discharge puru...
upper respiratory sy...
discharge; nasal
Chemical substances more
Faropenem daloxate
Defi
cladinose
Organisms more
Streptococcus pneumo...
Haemophilus influenz...
Moraxella catarrhali...
Organs and Body parts more
respiratory tract
Help us improve novo|seek
Please, take the survey
Results for sinusitis bacterial infections: Medline (1,866) | Full Text (119) | Grants (27)
Save search and create alerts | Export citations | Labels | Sort by date (newest first)
Ultrasound as a treatment for chronic rhinosinusitis.
Med Hypotheses 2009,Jul,01;73(1):15-7; (PMID: 19264415)
Bartley, Jim ; Young, Danuta;
[...]As antibiotics are largely ineffective in the treatment of bacterial biofilms, alternative therapeutic strategies including blocking molecular communication (quorum sensing) between bacteria, inhibiting biofilm matrix production and interventions that damage bacterial membranes are being explored as treatment options.[...]
Effectiveness of amoxicillin/clavulanate potassium in the treatment of acute bacterial sinusitis in children.
Pediatrics 2009,Jul,01;124(1):9-15; (PMID: 19564277)
Wald, Ellen R ; Nash, David ; et al.
[...]OBJECTIVE: The role of antibiotic therapy in managing acute bacterial sinusitis (ABS) in children is controversial. The purpose of this study was to determine the effectiveness of high-dose [...] receiving the placebo. CONCLUSIONS: ABS is a common complication of viral upper respiratory infections. Amoxicillin/potassium clavulanate results in significantly more cures and fewer failures than placebo[...]
A 51-year-old woman with acute onset of facial pressure, rhinorrhea, and tooth pain: review of acute rhinosinusitis.
JAMA 2009,May,06;301(17):1798-807; (PMID: 19336696)
Hwang, Peter H;

Figure 8.11 Novo|seek search on sinusitis and bacterial infections

PubMed EX. PubMed EX is a browser extension for Mozilla Firefox and Internet Explorer that mark up PubMed search results with additional information derived from data mining. PubMed EX provides background information that allows searchers to focus on key concepts in the retrieved abstracts.[42]

NCBI
PubMed
www.pubmed.gov
A service of the U.S. National Library of Medicine and the National Institutes of Health
My NCBI
[Sign In] [Register]
All Databases PubMed Nucleotide Protein Genome Structure OMIM PMC Journals Books
Search PubMed for sinusitis AND bacterial infections Go Clear
Advanced Search
Save Search
Clipboard
Limits Preview/Index History Clipboard* Details
Display Summary Show 20 Sort By Send to
All: 2885 Review: 644
Items 1 - 20 of 2885
Page 1 of 145 Next
Recent Activity
Turn Off Clear
1: Wald ER, Nash D, Eickhoff J.
Effectiveness of amoxicillin/clavulanate potassium in the treatment of acute bacterial sinusitis in children.
Pediatrics. 2009 Jul;124(1):9-15.
PMID: 19564277 [PubMed - in process]
Related Articles
2: el-Fiky LM, Khamis N, Mostafa Bel D, Adly AM.
Staphylococcal infection and toxin production in chronic rhinosinusitis.
Am J Rhinol Allergy. 2009 May-Jun;23(3):264-7.
PMID: 19490799 [PubMed - indexed for MEDLINE]
Related Articles
3: Cohen M, Kofonow J, Nayak JV, Palmer JN, Chiu AG, Leid JG, Cohen NA.
Biofilms in chronic rhinosinusitis: a review.
Am J Rhinol Allergy. 2009 May-Jun;23(3):255-60. Review.
PMID: 19490797 [PubMed - indexed for MEDLINE]
Related Articles
Information from MeSH
Sinusitis
An inflammatory process of the mucous membranes of the paranasal sinuses that occurs in three stages: acute, subacute, and chronic. Sinusitis results from any condition causing ostial obstruction or from pathophysiologic changes in the mucociliary transport mechanism.
PubMed
see more...

Figure 8.12 PubMed search on sinusitis and bacterial infections using a browser with the PubMed EX add-on

NLM Mobile. NLM Mobile includes several programs for Palm devices and Pocket PCs some of which can be used from the desktop These programs include AIDSinfo PDA Tools, WISER (Wireless System for first Responders, PubMed for Handhelds and the NCBI Bookshelf. [43]

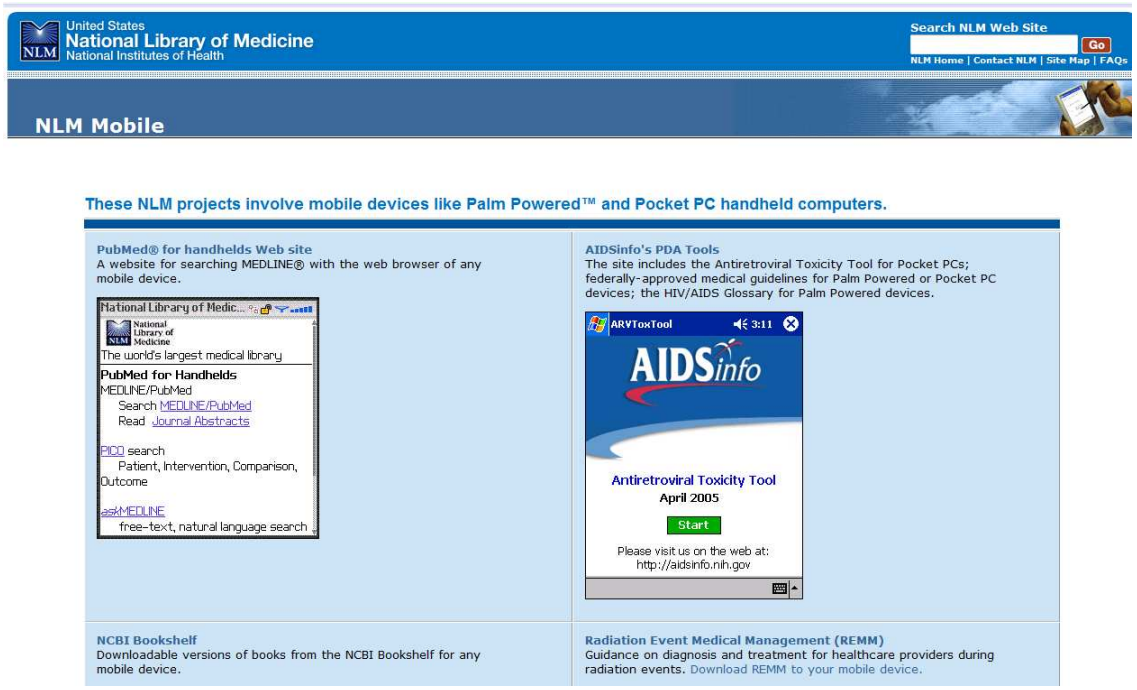

United States National Library of Medicine
National Institutes of Health
Search NLM Web Site
Go
NLM Home | Contact NLM | Site Map | FAQs
NLM Mobile
These NLM projects involve mobile devices like Palm Powered™ and Pocket PC handheld computers.
PubMed® for handhelds Web site
A website for searching MEDLINE® with the web browser of any mobile device.
National Library of Medic...
National Library of Medicine
The world's largest medical library
PubMed for Handhelds
MEDLINE/PubMed
Search MEDLINE/PubMed
Read Journal Abstracts
PICO search
Patient, Intervention, Comparison, Outcome
askMEDLINE
free-text, natural language search
AIDSinfo's PDA Tools
The site includes the Antiretroviral Toxicity Tool for Pocket PCs; federally-approved medical guidelines for Palm Powered or Pocket PC devices; the HIV/AIDS Glossary for Palm Powered devices.
ARVToxTool 3:11
AIDSinfo
Antiretroviral Toxicity Tool
April 2005
Start
Please visit us on the web at:
http://aidsinfo.nih.gov
NCBI Bookshelf
Downloadable versions of books from the NCBI Bookshelf for any mobile device.
Radiation Event Medical Management (REMM)
Guidance on diagnosis and treatment for healthcare providers during radiation events. Download REMM to your mobile device.

Figure 8.13 NLM Mobile (courtesy National Library of Medicine)

Key Points

- In spite of several criticisms of Google, it continues to be the search engine of choice for medical and non-medical searches
- Google Scholar is also a highly regarded search engine for medical searches
- For academic searches PubMed is considered the search engine of choice
- Newer excellent search engines continue to appear on the scene and be tested by patients and clinicians

Conclusion

At this time, Google is the premier search engine for non-medical and perhaps medical searches. With proper filtering and experience, Google can be used with significant success. Today the average person can search for answers to a variety of medical questions. Although this may produce some "cyber-hypochondria" in a minority of searchers, it is likely to produce better- informed patients in the majority. Better studies are needed to compare Google with other search engines and PubMed for quality and speed of retrieval. Familiarity with PubMed and its new features is important for healthcare workers who need to conduct formal searches of the medical literature. With knowledge and experience a PubMed search can result in relevant results in a timely fashion.

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9

Mobile Technology

ROBERT E HOYT

Learning Objectives

After reading this chapter the reader should be able to:

- Describe the history of medical mobile technology
- List the essential features of a personal digital assistant and smartphone
- Identify the limitations of hand held technology
- Compare and contrast the medical software programs most helpful for clinicians
- Describe the evolution from personal digital assistants to smartphones

"I have always wished that my computer would be as easy to use as my telephone. My wish has come true. I no longer know how to use my phone"
Bjarne Stroustrup

Had this section been written before 2006 it would have been given the title "Personal Digital Assistants and Medicine". With the advent of "smartphones" (PDA phones, BlackBerries, iPhones, etc), we feel that mobile technology is a more appropriate title. Mobile technology is a very logical transitional step from the personal computer. With improving speed, memory, wireless connectivity and shrinking size, consumers desire a more portable platform for their information and applications. Although mobile technology is not necessarily part of a Medical Informatics curriculum, widespread popularity of this technology in medicine makes it worth mentioning.

The history of personal digital assistants is quite recent. In the early 1990s the Apple Newton appeared with the hope that this new technology would appeal to the average user. This monochrome PDA weighed .9 lbs, measured 7.25 x 4.5 x .75 inches, had 150 K of SRAM, a processor speed of only 20 MHz, short battery life and cost $700.[1] It obviously did not succeed because it was too big, too slow, had insufficient memory, was too heavy and cost too much for the average consumer.

The next handheld product to catch the public's attention was the Palm Pilot 1000, invented by Jeff Hawkins in 1994 and released in 1996.[2] It was smaller, less expensive and had 128 K of memory. Synchronizing with the personal computer was a one-step operation. One could argue that the PDA did not become popular with the medical profession until the "*killer application*" Epocrates was released in 1999.[3] First, there was the excitement of knowing that drug facts could be retrieved much more rapidly with the PDA compared to the Physician Desk Reference (PDR) and secondly, the program was free. The PDA was also a platform to store all medical "pearls" rather than stuffing notes into the pockets of a white coat.

Other companies got on the bandwagon to produce PDAs; Hewlett-Packard produced the iPaq while Dell and Sony have since abandoned the PDA market. Microsoft's Windows operating system (OS) made major inroads into what initially was mainly Palm OS territory for the medical profession. Symbian and Linux are also operating systems that can be used in the PDA but are not prevalent in the United State's PDA or smartphone market. BlackBerry by Research in Motion is

extremely popular for e-mail and now has multiple medical software programs. Newer platforms to host medical programs such as Mac OS X (iPhone) and Android (G-phone) appeared which we will cover later in this chapter.[4]

Mobile Technology Popularity

According to a 2006 study in the Journal of General Internal Medicine, 50 percent of practicing physicians and about 60-70 percent of medical students used PDAs on a regular basis.[5] Many medical schools fully support handheld technology as part of their educational programs. Figure 9.1 shows the adoption rate of mobile devices based on four surveys.[6] PDA use by clinicians almost quadrupled in just six years.

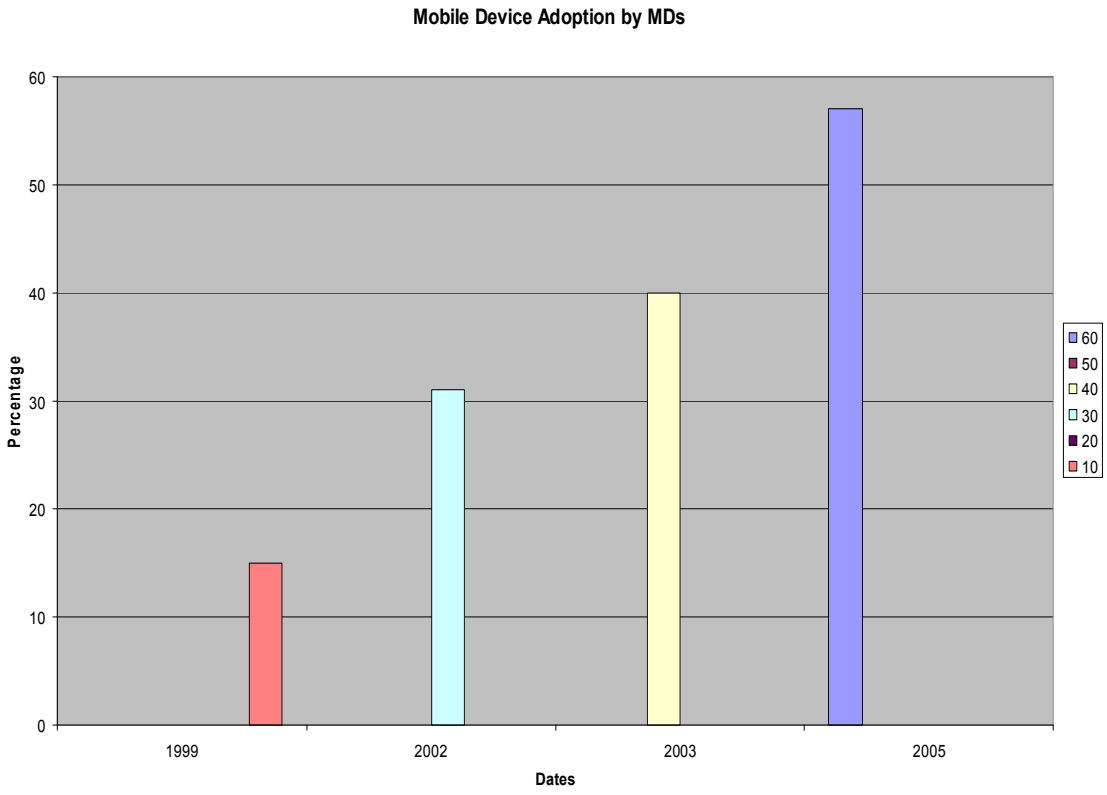

Figure 9.1. Popularity of PDAs by physicians

Figure 9.2 was adapted from a 2004 article in the journal Pediatrics by Carroll et al and shows the most common uses of PDAs by pediatricians.[7] As multiple studies have shown, a drug reference is listed as the most frequently used PDA or smartphone program. Personal scheduling is listed second because most people need to keep track of their schedules and most programs synchronize with Microsoft Outlook. Perhaps this category also included contact information, as that is also a major benefit of handheld technology. Note that most people did not use a PDA to: store patient information, e-prescribe, access the Internet or submit a bill. The PDA does not excel in those areas due to a small screen size, an inadequate keyboard and the need for more complicated and

expensive software. It also requires more complex training that is difficult to achieve in a private practice setting. On the other hand, PDAs are great for simple medical calculations. Smartphones are accessing the Internet more rapidly which may change how clinicians view handheld technology.

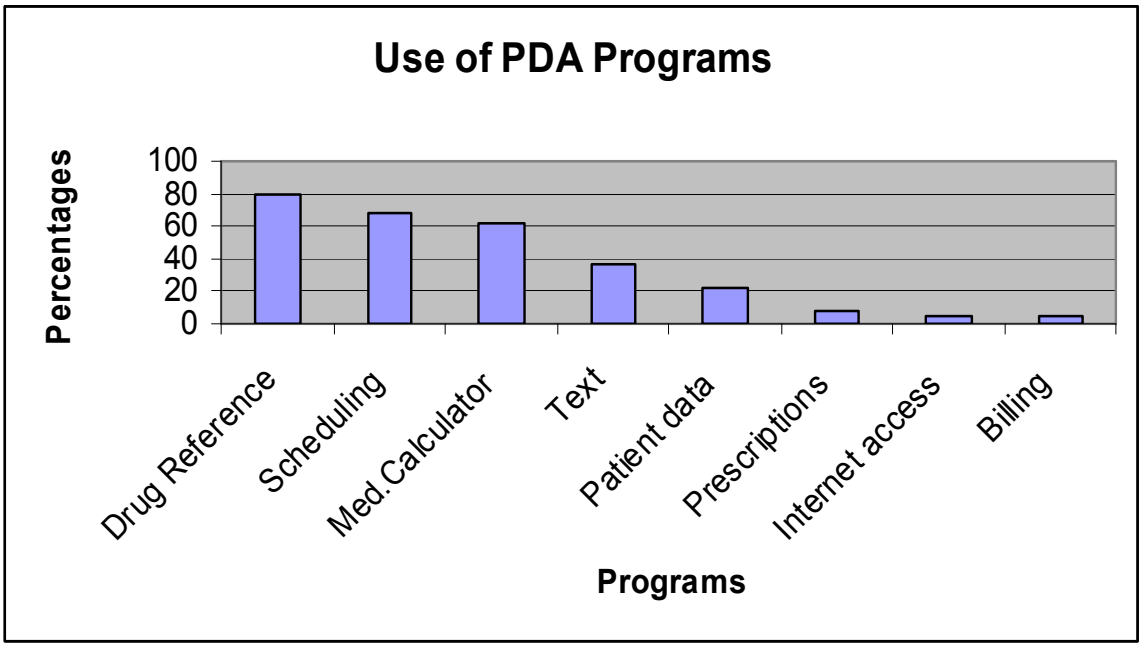

Figure 9.2 Most common uses of PDAs by Pediatricians (2004)

The shift from PDAs to smartphones has been rapid, occurring over only 6-8 years. Manhattan Research reported in early 2009 that sixty four percent of physicians use smartphones compared to 30% in 2001.[8]

There is no industry-wide definition of a smartphone. Some define it as having an operating system and others define it as simply having more functionality than conventional cell phones. For the purpose of this chapter we will use the term smart phone and include only those that have operating systems capable of hosting medical software. With the evolution to cloud computing, more and more medical programs will be hosted on the cloud and not on the device. Therefore, one could eventually state that a smartphone is one that is Internet capable.

Later in this chapter we will discuss each operating system with an example of a smartphone newly available in 2009 for each platform.

Basic Organizer Functions

All smartphones have basic PDA organizer functions such as contacts, calendars and the ability to record memos, tasks and store passwords. This allows medical workers to synchronize their work calendar to their smartphones. Google mobile has the feature of synching its calendar feature to multiple smartphones running the Android, Mac OS X, Windows Mobile, Symbian and BlackBerry operating systems.[9]

These organizer features synchronize with a personal information manager (PIM) that is part of the desktop software. Figure 9.3 shows screen shots of the calendar and contact features of the Windows operating system.

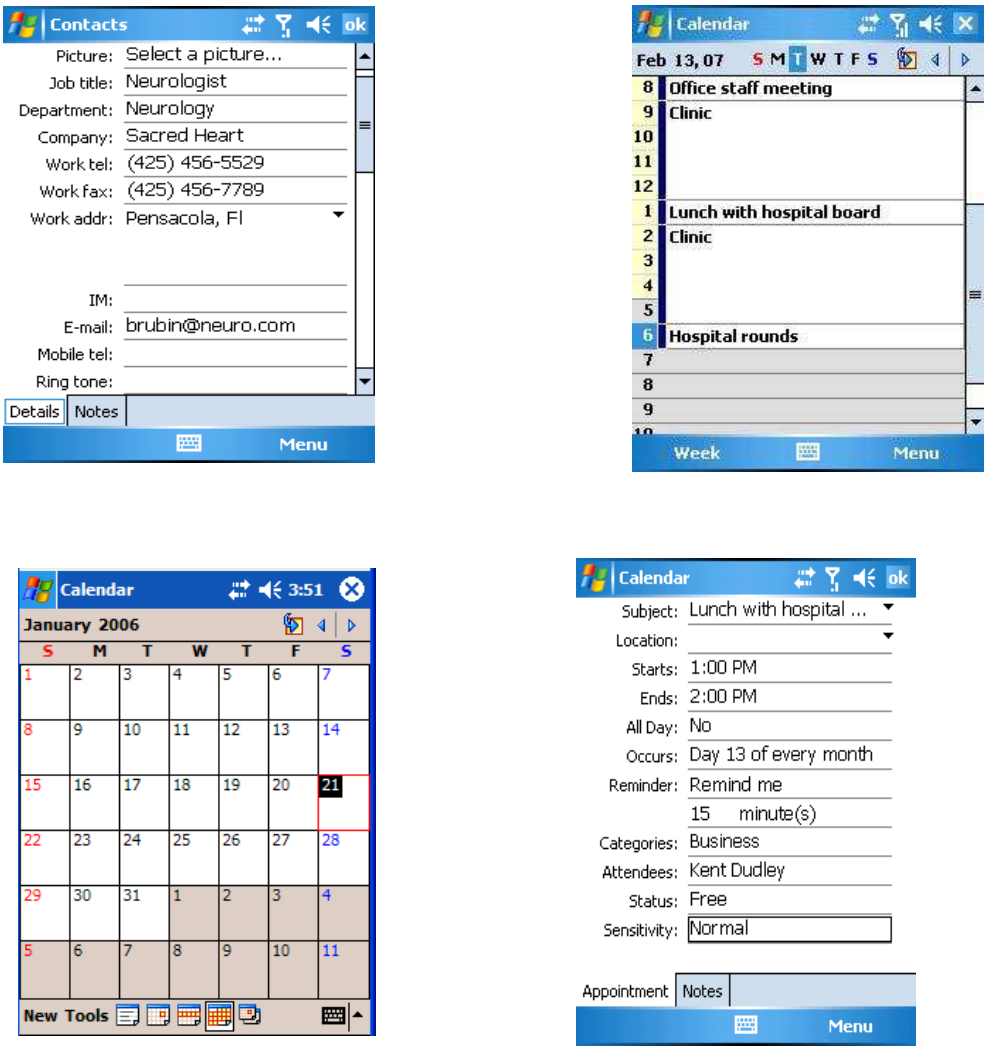

Figure 9.3 Windows OS calendar and contact features

Medical Software Programs

Calculators

The first four calculators discussed are available on the StatCoder web site. It also has calculators for the risk of stroke and atrial fibrillation.

1. **Cardiac Clearance.** A free program that offers two nationally recognized algorithms for cardiac clearance before surgery. Simply tap on a few screens to answer standard questions and it tells you if the patient needs further testing prior to going to the operating room. Available only for Palm OS.[10]

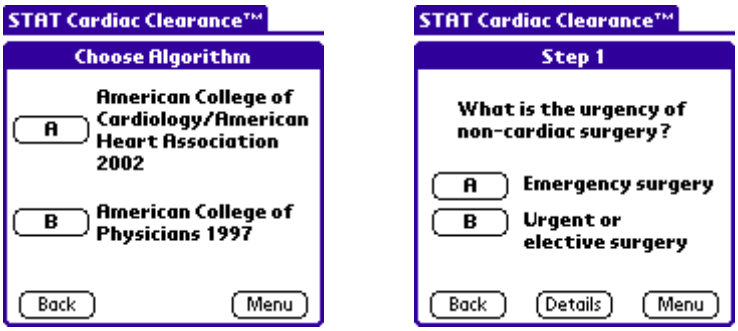

Figure 9.4 Cardiac Clearance

2. **Cholesterol.** This software for Palm OS is based on the national Adult Treatment Panel (ATP) III guidelines. Below, we selected a female age 60-64 with a high LDL (bad) and high HDL (good) cholesterol (a common scenario in older women) (Fig. 9.5). If she has no other risk factors to input, press calculate and you will see in figure 9.6 that her actual risk for coronary heart disease over the next 10 years is only 3%; whereas the average for her age is 12%. This program estimates the 10 year risk of heart disease and offers treatment recommendations within the same program. [10]

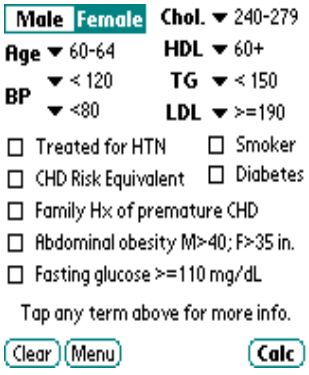

Figure 9.5 Patient risk factors

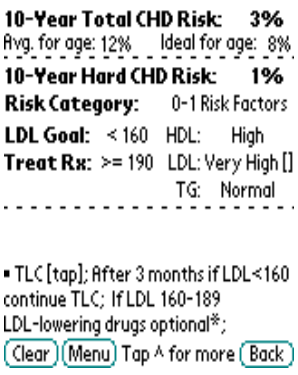
10-Year Total CHD Risk: 3%
Avg. for age: 12%
Ideal for age: 8%
10-Year Hard CHD Risk: 1%
Risk Category: 0-1 Risk Factors
LDL Goal: < 160
HDL: High
Treat Rx: >= 190
LDL: Very High []
TG: Normal
• TLC [tap]; After 3 months if LDL<160 continue TLC; If LDL 160-189 LDL-lowering drugs optional*;
Clear
Menu
Tap ^ for more
Back

Figure 9.6 10-Year total CHD risk

3. **Depression.** A free program that uses a standard depression questionnaire and calculates the degree of depression.[10]

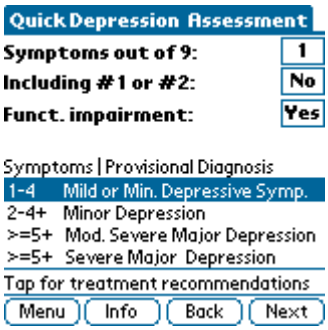
Quick Depression Assessment
Symptoms out of 9: 1
Including #1 or #2: No
Funct. impairment: Yes
Symptoms | Provisional Diagnosis
1-4 Mild or Min. Depressive Symp.
2-4+ Minor Depression
>=5+ Mod. Severe Major Depression
>=5+ Severe Major Depression
Tap for treatment recommendations
Menu Info Back Next

Figure 9.7 Depression assessment

4. **Growth Charts.** A free program that inputs the age, gender, height and weight and plots how the child compares to normative data.[10]

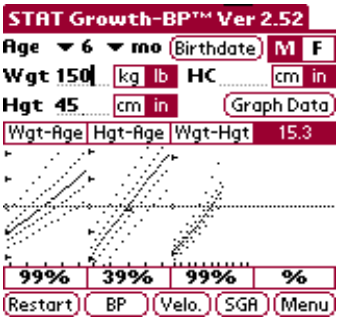
STAT Growth-BP™ Ver 2.52
Age 6 mo Birthdate M F
Wgt 150 kg lb HC cm in
Hgt 45 cm in Graph Data
Wgt-Age Hgt-Age Wgt-Hgt 15.3
99% 39% 99% %
Restart BP Velo. SGA Menu

Figure 9.8 Growth Charts

5. **MedCalc.** A very popular free Palm OS, Pocket PC and iPhone program with over 75 commonly used formulas. You can customize the choices for only those formulas you use most often. It includes IV infusion rate calculators that should improve medication safety.[11]

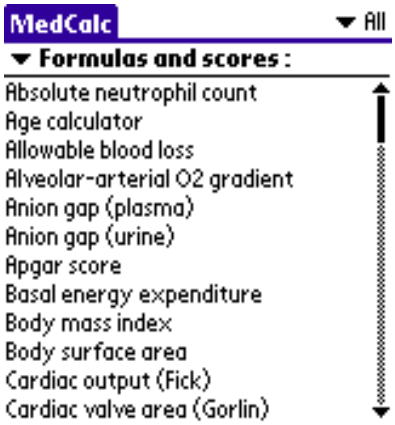

Figure 9.9 Main screen

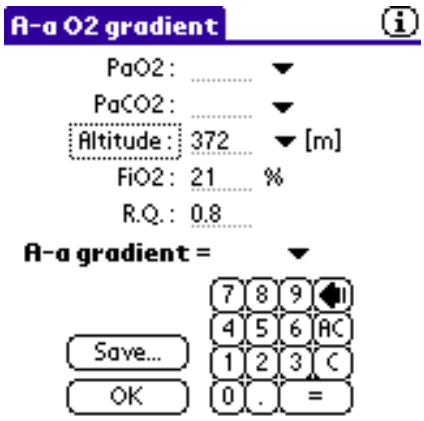

Figure 9.10 Calculating the A-aO2 gradient

6. **Archimedes.** A free program for Palm, iPhone, BlackBerry, Windows Pocket PC and Windows Mobile OSs that is similar to Medcalc.[12]

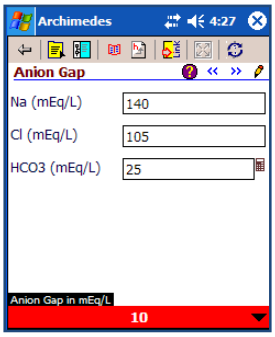

Figure 9.11 Anion gap

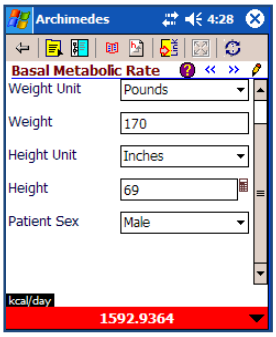

Figure 9.12. Basal Metabolic Rate

7. **ABG Pro.** A free Palm OS program that interprets arterial blood gases.[13]

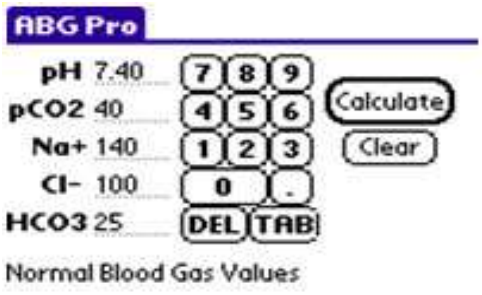

Figure 9.13 ABG Pro

8. **Preg Track.** Another free Palm OS program that tracks pregnancies and a desktop version is also available.[14]

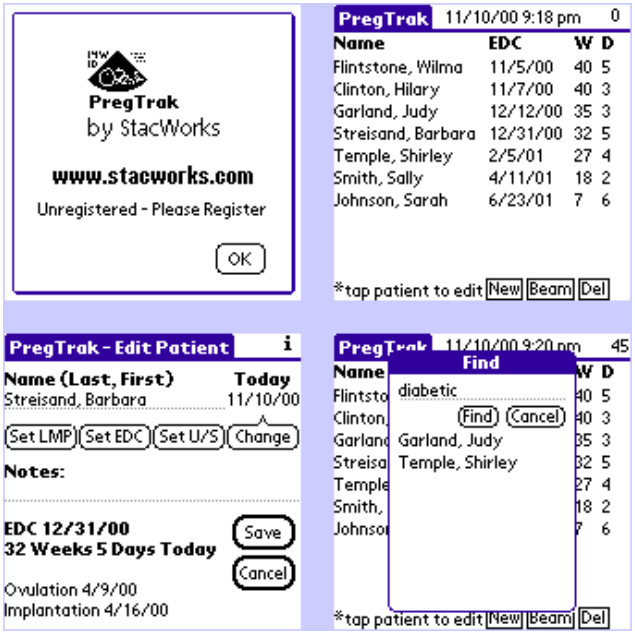

Figure 9.14 Preg Trak

9. **Evidence Based Medicine (EBM) Calculator.** A free program available for both the Palm OS and Windows OS systems. It calculates the relative risk reduction (RRR), the absolute risk reduction (ARR) and the number needed to treat (NNT) for random controlled trials (RCTs).[15] We will discuss this in more detail in the chapter on EBM.

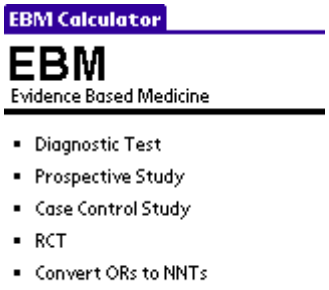

Figure 9.15 EBM Calculator

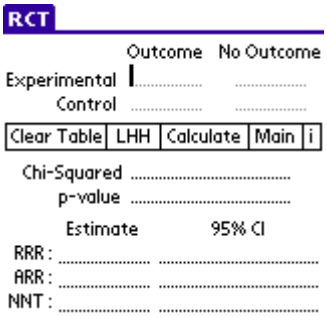

Figure 9.16 Random Controlled Trial

10. **Others.** We should note that Epocrates also offers the following free PDA calculators or "tools": drip rate calculator, cholesterol tool, MedMath, BMI tool, bone health tool, corticosteroid converter, depression assessment, cardiology essentials, heparin dosing, INR calculator, insulin calculator, temperature converter, topical steroid tool, tumor staging, hypertension tool, narcotic analgesic converter and GFR calculator.[16] ICU Math Medical calculator for the adult ICU uses 85 medical equations, including pulmonary, cardiology, BNP-CHF nomogram, pharmacokinetic dosing, renal, electrolyte, chemistry, nutrition, TPN, peri-operative risk, biostatistics, ACLS, Apache II, unit conversions and rules of thumb.[17]

Textbooks for Mobile Technology

Trying to read a textbook on a small screen will not appeal to everyone. Nevertheless, there are many textbooks available for use on handheld technology. As a result of secure digital cards many textbooks can be stored on a memory card, thus saving space on the internal handheld memory. One of the most popular sites for e-textbooks for mobile technology is Skyscape.[12] They offer over 300 titles covering primary care and multiple specialties. MobiPocket is another company that sells medical e-books that require a special reader downloaded to the smartphone.[18]

Popular General Medical Software

Multiple medical PDA programs are available as freeware, shareware and fee-based programs. See Table 9.1 Too many software programs exist to mention all of them so we will highlight a few:

Shots 2009. A free program for Palm and Windows operating systems that is a good resource for childhood immunization schedules.[19]

US Preventive Services Task Force Tool. A free calculator program that provides the most recent national recommendations for screening and prevention, based on age, gender, etc. For Palm and Windows OSs.[20]

Table 9.1. General medical software for PDAs and smartphones

Website	URL	Platforms supported	Cost
Electronic Preventative Services Selector	http://epss.ahrq.gov/PDA/index.jsp	BB, P, WM	Free
Engadget Mobile	www.engadgetmobile.com	BB, P, IP, PPC, WM, S	Free
Epocrates	www.epocrates.com	BB, P, PPC, WM, IP	Free
Freeware Palm	www.freewarepalm.com	P	Free
Handango	www.handango.com	A, BB, P, WM, S	$
HanDbase	www.ddhsoftware.com	BB, P, IP, PC, WM, S	$
iSilo	www.isilo.com	A, BB, IP, PPC, WM, S	$
Lexi-Comp	www.lexi.com	BB, IP, P, PPC, WM	$
MedCalc	www.med-ia.ch/medcalc	P, IP, WM	Free
Medical Pocket PC	www.medicalpocketpc.com	BB, P, S, WM	$
MeisterMed	www.meistermed.com	A, BB, IP, PPC, WM, S	$, Free
MemoWare	www.memoware.com	A, BB, IP, PPC, WM, S	Free
Mobile MerckMedicus	www.merckmedicus.com	P, PPC, WM	Free
MobiPocket	www.mobipocket.com	BB, P, PPC, WM, S	$
Palm Doc Chronicles	www.palmdoc.net	A, BB, IP, PPC, WM, S	Free
PalmGear	www.palmgear.com	A, BB, WM, S	$
PDA Medisoft	www.pdamedisoft.com	BB, P, PPC, WM	$
PDA TopSoft	http://medical-software.pdasoft.com	BB, P, PPC, WM, S	$
PDR (Thompson Clinical Xpert)	www.pdr.net	P, PPC	Free
Pepid	www.pepid.com	BB, IP, P, PPC, WM	$
Pocketgear	www.pocketgear.com	BB, P, PPC, WM	$
QxMD	www.qxmd.com	BB, IP	Free
Sanford Guide	www.sandfordguide.com	BB, P, PPC	$
Shots 2009	www.immunizationed.org	P, PPC	Free
Skyscape	www.skyscape.com	BB, P, PPC, WM, IP, S	$
StatCoder	www.statcoder.com	P, IP, WM	S, Free
Tarascon	www.tarascon.com	BB, P, WM	$
Unbound Medicine	www.unboundmedicine.com	BB, IP, P, PPC, WM	$
USBMIS	www.USBMIS.com	BB, P, WM	$, Free

Pneumonia Severity Index. This free program calculates the severity and mortality of community acquired pneumonia. For Palm and Windows OSs.[21]

TB Treatment Guidelines. Originates from the Centers for Disease Control and is available for Palm OS only.[22]

MeisterMed. A popular site for Palm and Pocket PC users created by the Family Physician Dr. Andrew Scheckman. The programs are very well written and are free or fee-based. All require the document reader iSilo.

- Free: LyteMeister, AsthmaMeister, DermMeister, PapMeister, STD 2006, Thoracentesis, Central Line Placement, Antibiotic Prophylaxis, Generalized Anxiety Disorder Assessment Tool, PediPercentile, Life Expectancy, Medicare Preventive Services, Influenza 2007-2008, Breast Feeding and Splinting Manual. There is also a Medical iSilo Depot that has multiple contributed programs covering most specialties that are either free or are offered as a trial demo
- Fee based: ICD Meister (covers 15,000 ICD codes), Procedure Code Meisters (CPTs) and NCD Meister (Medicare National Coverage Determinations)[23]

There are simply too many PDA and smartphone medical software programs to list. A May 2009 search for the word "medical" at Palmgear returned 617 software programs for the smartphone.[24]

Drug Programs for Mobile Platforms

At least ten drug programs are available for the PDA or smartphone. Without question, the most popular has been Epocrates, because it was the first available, was intuitive, innovative and inexpensive. See figures 9.17-.9.19 for screen shots of Epocrates that demonstrate its intuitive nature. According to a study at the Brigham and Woman's Hospital regarding the use of Epocrates: 82% thought it helped inform patients; 63% thought it reduced adverse drug events and 50% thought it reduced about one medication error per week.[25] A more recent 2006 study of 3600 users of Epocrates showed that the majority accessed this program more than 6 times daily and about 40% used it for more than 50% of patient encounters.[26]

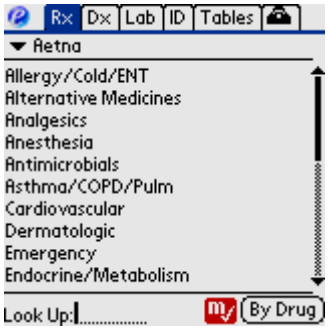

Figure 9.17 Drug families

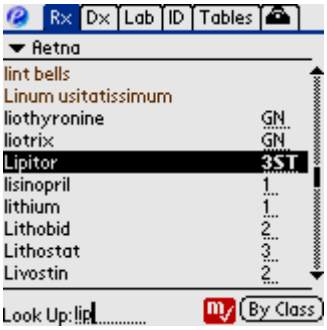

Figure 9.18 Drug selection

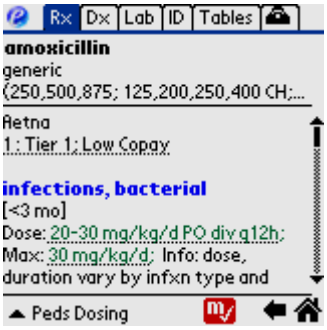

Figure 9.19 Drug specifics

Epocrates also has the following valuable standard features:

- The Medicare part D formulary that is important with new prescription benefits and e-prescribing
- Continuing medical information (CME). Users can fulfill their state-specific requirements with this option
- MedTools is a set of free medical calculators
- Doc Alerts are medical alerts and news downloaded to your smartphone
- Local formulary hosting is available at an additional cost

- Black box warnings, therapeutic drug levels, renal and hepatic dosing, monitor parameters, pregnancy and lactation warnings and pharmacology (metabolism, excretion, drug half life, mechanism of action and drug class)
- Epocrates Patient Snapshot is a 2009 program that allows a patient to designate a physician to access their Google Health profile. A physician must sign up for the program and obtain an ID. A patient can then designate an Epocrates-using physician to access their profile
- Epocrates OTC drugs in a new mid-2009 offering that is available with their premium software programs only

As of June 2009, Epocrates is available for Palm, Windows, BlackBerry and *i*Phone OSs as the following programs:

1. **Epocrates Rx.** A free program with more limited drug content than fee based programs. All Medicare part D formularies became available for free in January 2008. Special discounted pharmacy deals from Target and Kmart are now available as separate formularies.
2. **Epocrates RxPro.** Provides the drug program plus an infectious disease (ID) program. Program covers 3,300 brand/generic drugs and 600 alternative drugs for $60/year or $99/2 years.
3. **Epocrates Essentials.** Includes a drug program, an infectious disease (ID) program, a lab test reference, symptom assessment and disease monographs. Option is $149/year or $249/2 years.
4. **Epocrates Essentials Deluxe.** Includes the Essentials package plus a medical dictionary (100,000 terms) and a coding tool (ICD-9 and CPT). Cost is $199 for one year, $299 for two years.[16]

Tarascon Pharmacopeia. It is similar to the popular pocket book and is available for Palm, BlackBerry and Windows OSs. Simple to use with limited bells and whistles and costs only $27 yearly.[27]

Thomson Clinical Xpert. This program is available free for Palm or Windows OSs. It has a drug database, drug-drug interactions, toxicology, lab test resource, disease databases, calculators and medical news. Program size is about 25 MB.[28]

Gold Standard's Clinical Pharmacology OnHand. Basic module has features similar to the other programs mentioned. Companion modules are: drug iDentifier, IV Alert and InFormulary. Future modules are Calculators and ACP Pier. Currently available for Palm or Windows OSs. Basic module costs $99; addition of iDentifier and IV Alert adds $88.[29]

Physician Drug Handbook. Handbook has all of the basic features already discussed and available for multiple operating systems. It is one of 32 pharmacy related textbooks for the smartphone available at Skyscape, at a cost of $60.[12]

Infectious Disease Programs

After calculators and drug programs, the next most popular downloadable category for the smartphone is Infectious Disease (ID) programs. Like drug programs they provide quick answers to straightforward questions. According to one study, infectious disease programs for the handheld were found to be a good reference for a majority of general internal medicine hospital admissions with infectious disease conditions.[30] These programs may not be able to answer highly complicated

questions, however. For an excellent review of the following three programs, we refer you to an article by Miller.[31]

Epocrates ID. This program can only be purchased as part of another Epocrates program. Sections are organized by bug, drug or location. It is intuitive and integrated with the Epocrates drug program. In figures 9.20-9.22, for example, if you decide to use vancomycin, it is hyperlinked back to the drug database which reduces the amount of taps of the stylus or touches.[16]

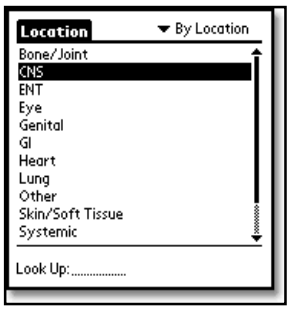

Figure 9.20 Location

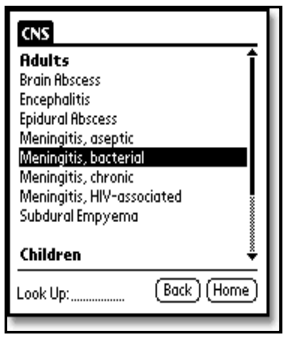

Figure 9.21 Meningitis chosen

Figure 9.22 Therapy choice

Sanford's Guide to Antimicrobial Therapy. The electronic version of the highly popular handbook is updated yearly. It is available for Palm, Windows and BlackBerry OSs with an annual cost of $29.99.[32]

Johns Hopkins Antibiotic Guide. The Editor-in-Chief is the well-respected John Bartlett MD. The program is available as a desktop or smartphone program with auto-updates. The program was upgraded in September 2007 to include sections on diagnosis, drugs, pathogens, management and vaccines. The program became fee-based in February 2008 and costs about $2 monthly. It is now available for the Palm, Windows Pocket PC and BlackBerry platforms through Skyscape.[12]

Database Programs

Because most handheld operating systems retrieve and calculate data rapidly, a database program can be a valuable addition. Several excellent mobile database programs exist, but only one program will be discussed.

HanDBase. This program creates a database on your desktop that you can send to a PDA or smartphone. Simply set up the fields, like name and beeper, with the characteristics you want the field to have and save with a name such as "Pagers July 2002". The database is created and saved on both your PC and your handheld. You can create small databases for inventories, lists of all of your usernames and passwords and so forth. It's easy to add a password to keep your information secure. The software is available for Palm, Windows, iPhone, Symbian and BlackBerry OSs. HanDbase is a relational database and not a flat file, so one database can be related to another database. The professional version comes with "Forms" that provides an attractive "front end" for data to be entered. See an example of forms in figure 9.24 below. Over 2000 free databases are already created and available on the website; all you have to do is fill in the data. As an example, you can find a patient tracking or a wine inventory database. Databases can also synchronize to Microsoft Excel and Access. The cost for the professional version is $39.[33]

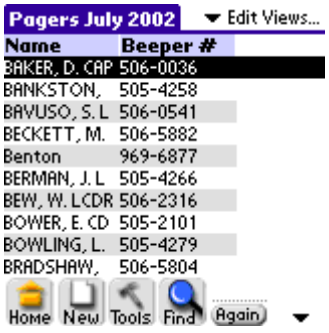

Figure 9.23 Simple database

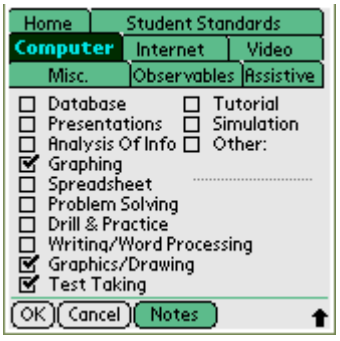

Figure 9.24 Form interface

Document Readers

PDAs and smartphones will not automatically read every software program or document. While searching commercial medical software web sites you will occasionally see the comment that you need a document reader. There are numerous good products on the market but only two will be discussed.

iSilo. With this program you can read documents that you download or create. Using iSilo (and iSiloX), one of the authors converted a very lengthy guideline to prevent blood clots (DVTs) in hospitalized patients to the handheld format. Because the program was written in html you can easily hyperlink one page to another. After a few screen taps, you can find the answer. iSilo is available for Palm, Windows, iPhone, BlackBerry and Symbian OSs. The program will allow rich text, images and tables to be added. The cost of this reader is $20 and that includes frequent upgrades.[34]

iSiloX is a free desktop program that converts html documents, text documents and images so they can be seen on your handheld (in the iSilo document reader). The DVT program below was converted with iSiloX. This also means you can capture images, such as the coronary arteries, etc on your smartphone to show patients.[35]

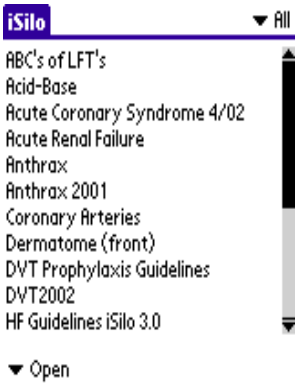

Figure 9.25 Multiple documents

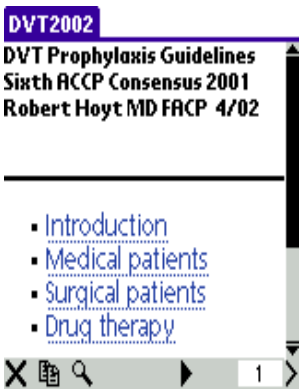

Figure 9.26 DVT Guidelines

Figure 9.27 Hyperlinks

MobiPocket Reader. This free program for the Palm, Windows mobile, BlackBerry and Symbian OSs allows the reader to read e-books and access approximately 900+ fee-based medical e-books on their mobile platform. With the free MobiPocket Creator program you can create a simple e-book or database for download to your favorite mobile platform. E-books can be created by automatic conversion of Word documents, simple text and pdfs.[36]

Patient Tracking

Very few clinicians are willing to manually input patient data into their PDA or smartphone on a regular basis. It sounds impressive to say that you have all of your patient data on your smartphone but the reality is, this is very time consuming. As mentioned, HanDbase has several free databases that could be used in this manner. Another program called Patient Tracker offers a mobile (Palm and Windows Os) solution for $30.[37] Another similar product is Patient Keeper, with the exception that they also offer an enterprise solution that links to the hospital information system in order to retrieve lab data, capture charges, perform mobile dictation, send e-prescriptions and access a reference library.[38]

Patient Billing

Mdeverywhere EveryCharge. This billing program enables practices to enter charges into a Palm PDA or via the web on your desktop computer. A rules engine automatically identifies errors in charges to ensure accuracy and HIPAA compliance. EveryCharge "prompts the referring physicians, compares diagnoses and procedure code compatibility, includes payer-specific application rules, features an evaluation and management (E & M) coder and much more".[39]

StatCoder E & M. This is a simple program that calculates the correct evaluation and management (E & M) code by simply clicking on elements in several fields. The program costs $75 for two years and includes a free trial. [10]

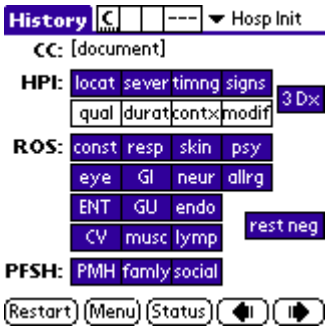

Figure 9.28 StatCoder E&M

E-prescribing

E-prescribing will be discussed in detail under the chapter on e-prescribing.

Forms on the Mobile Platform

Pendragon Forms. With this program you can create customizable surveys. As an example, home health nurses could record the status of a patient and synchronize the information to the office PC at the end of the day. Data is uploaded as an Excel file that saves time and money by going paperless.

Data can also be synchronized to Microsoft Access or a SQL server. The company also offers the ability to synchronize to a remote server so workers from multiple areas can send information to a head office. Cost for an individual license of version 5.1 is $299 and is available for Palm and Window OSs. A two week free trial is available.[40]

Smartphones

As previously noted, we defined smartphones as having an operating system allowing for medical programs to be installed. In reality they offer much more to include e-mail, Internet access, camera and video capability. Synchronization to a computer can be by Bluetooth, WiFi or a USB connection. Touch screens have made data entry easier, compared to a stylus. Internal memory is no longer an issue with mini SD cards available in the 1-16 GB range. Not that long ago physicians may have carried a pager, cellphone and PDA. Now we are logically moving in the direction of a single multi-purpose device. Physicians can receive routine phone calls, text messages or voice mails, rather than the traditional beep.[41] Moreover, with much faster Internet access we can anticipate more interest in using smartphones to e-prescribe, access online resources, access EHRs and many more functions. NextGen and Allscripts, for example, offer access to their EHRs via the iPhone.

Since December 2005 most carriers offered the benefits of faster 3 G networks, with 4 G speeds around the corner. Currently AT&T and T-Mobile use HSDPA networks, while Sprint and Verizon use EV-DO Rev. A. These services offer a download speed of about 1.5 Mbps. In the near future we will experience Mobile WiMax and LTE that should offer download speeds in the 2-6 Mbps range.[42] For additional information about 4 G networks, see the chapter on networks.

More web sites are producing mobile versions of their web sites to accommodate the smaller screen size. As of the first quarter of 2009, BlackBerry Curve, Storm and Pearl occupied the number 1, 3 and 4 spots for smartphone sales and the iPhone was number 2.[43] For further reading on the various platforms and specific phones we refer you to this resource.[44]

Too many smartphones are being produced monthly to possibly discuss each one. Instead, we will discuss the mobile operating systems and highlight their similarities and differences. Table 9.1 will give an example of a popular smartphone in each operating system category. The following are operating systems for smartphones currently available:

1. **Android .** One of the newer operating systems from Google and offered in 2009 for the T-Mobile G1, HTC Magic and HTC Dream phones. Expect many new phones with this operating system later in 2009. This open source OS is based on the Linux kernel and available to developers worldwide to create new medical and non-medical applications. The G-phone has a touch screen, trackball and QWERTY keyboard. As anticipated, this OS is seamlessly integrated with Google G-mail, Calendar, Maps and Chrome Lite browser. In 2009 there are very few medical programs available for this platform. In August 2009, an upgrade to G3 became available and it no longer included a keyboard.[45]
2. **BlackBerry**. BlackBerry has been known for its excellent platform to receive and send e-mail, but since late 2007 they have become a more valuable platform for the medical profession because of expanding medical software. In mid-2008 the BlackBerry 9000 (Bold) was released that included a faster HSDPA network, a faster processor at 624 MHz, more memory at 1GB, GPS, WiFi and a sharper screen. The BlackBerry 8900 (Curve) was also recently released with many similar features to the BOLD but with a sharper screen and ability to place phone calls via WiFi. Later in 2008 the touch screen BlackBerry 9530 (Storm) was released and its features are outlined in Table 9.2. It is rumored that Storm 2 will be released later in 2009. Like the iPhone, an application store was opened in early 2009 for

the BlackBerry. Below are screen shots of a homegrown antibiogram installed on the BlackBerry created with the database program HanDBase and the reader/creator program MobiPocket.

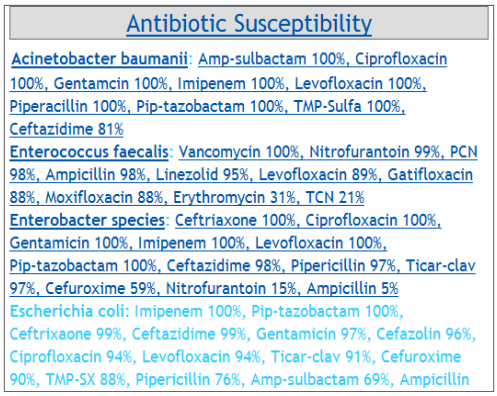
Antibiotic Susceptibility
Acinetobacter baumanii: Amp-sulbactam 100%, Ciprofloxacin 100%, Gentamcin 100%, Imipenem 100%, Levofloxacin 100%, Piperacillin 100%, Pip-tazobactam 100%, TMP-Sulfa 100%, Ceftazidime 81%
Enterococcus faecalis: Vancomycin 100%, Nitrofurantoin 99%, PCN 98%, Ampicillin 98%, Linezolid 95%, Levofloxacin 89%, Gatifloxacin 88%, Moxifloxacin 88%, Erythromycin 31%, TCN 21%
Enterobacter species: Ceftriaxone 100%, Ciprofloxacin 100%, Gentamicin 100%, Imipenem 100%, Levofloxacin 100%, Pip-tazobactam 100%, Ceftazidime 98%, Pipericillin 97%, Ticar-clav 97%, Cefuroxime 59%, Nitrofurantoin 15%, Ampicillin 5%
Escherichia coli: Imipenem 100%, Pip-tazobactam 100%, Ceftrixaone 99%, Ceftazidime 99%, Gentamicin 97%, Cefazolin 96%, Ciprofloxacin 94%, Levofloxacin 94%, Ticar-clav 91%, Cefuroxime 90%, TMP-SX 88%, Pipericillin 76%, Amp-sulbactam 69%, Ampicillin

Figure 9.29 Antibiogram (HanDBase)

Figure 9.30 Antibiogram (MobiPocket)

Enterprise Business (WLAN) solutions are available to incorporate nurse call functions, lab data, decision support, alerts, charge capture, e-prescribing, bar coding and RFID. Enterprise solutions allow for group e-mails to be pushed to clients.[46]

3. **iPhone and iPod Touch .**Without a doubt, the operating system to receive the most buzz in the past 2 years has been the iPhone. In its first 3 months, Apple sold about 1 million iPhones. It was the first touch screen smartphone that was easy to navigate and robust in web applications. The web experience is enhanced by its Safari browser and large screen. Within a year most medical software companies had created popular solutions for the iPhone. Some would argue that the BlackBerry platform is for those who use e-mail extensively and the iPhone for those who spend a lot of time on the Web. In the last year the iPod Touch has become another Apple platform for medical programs because, in essence, it has the iPhone capabilities without the phone feature and is less expensive. In 2009 there were more than 100 medical applications available through the iTunes app store as well as 50,000 non-medical applications. Significant improvements occurred with an OS3 upgrade that includes: a system wide search, keyboard in landscape mode, cut and paste capability, multimedia messaging and voice control of contacts and music. The newer iPhone 3 G S was released in June 2009 and included these upgrades plus: built in compass, video recording capability, faster application launching, memory increase to 32 GB, better 3-D graphics, better camera and voice memos. It is rumored that the new phone will allow for the uploading of medical device data such as blood glucoses via Bluetooth or cable. One significant drawback of the iPhone is the fact that the battery will likely need to be replaced each year for about $80 plus shipping.[47] Most of the popular medical software programs, like Epocrates are available for this platform and in addition the following programs are offered:

- Netter's Anatomy $39.99
- iChart EMR with iPrescribing, iBilling, iLab Reports and iNotes for $139.99
- LifeRecord: a comprehensive standalone EMR for $9999
- Other EMRs available on the iPhone: AllScripts
- Open source radiology (image) DICOM viewer known as Osirix, available for $19.95
- DynaMed online resource

- AirStrip OB: a program that makes neonatal monitoring strips possible on multiple platforms to include the iPhone[48]

4. **Palm.** Palm was the first operating system (Palm Garnet OS) offered on early PDAs and as a result this platform probably has more medical software programs than any other. Because its OS is considered outdated and sales of Palm PDAs faltered, they have migrated to the newer Palm Pre we will discuss in the next section. Palm has a simple, intuitive and reliable OS and this explains the initial success of the Palm Treo phone.[49]
5. **Palm Pre.** In an effort to stay competitive in the smartphone arena, Palm Pre utilizing WebOS (Linux derived) was released in June 2009. Although it will be available through Sprint initially, it will be offered by many more carriers within a year. This platform will also offer a touch screen as well as a Qwerty slideout keyboard. It will not offer additional memory with a memory card but will offer unique wireless charging with electromagnetic induction. The Pre will be able to automatically consolidate contact, e-mail and calendar information from multiple sources to include Google, Outlook and Facebook. You can connect with friends via text messages, instant messaging, e-mail, phone calls or Facebook. This will be the first smartphone to allow for multitasking; new pages like a deck of cards will appear so that e-mail and example calendar functions will be accessible at the same time. Palm Pre will include a program known as Classic, an emulator that allows viewing of older Palm software programs.[49]
6. **Symbian.** This operating system is prominent in Europe but not the United States**.** As of 2009, there are limited medical software programs for this OS.[50] In 2008, The Symbian Foundation was created to promote the use of the new open source Symbian operating system [51] Clearly, this effort was intended to compete with open source Android and the myriad of applications being developed for all smartphone operating systems. The largest Symbian smartphone platform is Nokia and the E71 phone details are presented in the Table 9.2.
7. **Windows Pocket PC and Windows Mobile.** Before the emergence of BlackBerry and the iPhone the Windows operating system was clearly competitive with Palm. One of the attractions was the ability of this OS to integrate well with standard Microsoft Office applications, Microsoft Outlook and a mobile version of Internet Explorer. Pocket PC is actually the hardware specification for the Microsoft handheld computer, whereas Windows Mobile is the operating system. At the time that Windows Mobile 6 was announced Microsoft stopped using the name Pocket PC. Devices without a phone are called Windows Mobile Classic devices, whereas devices with a phone and touch screen are called Windows Professional devices. Those devices without a touch screen but with a phone are called Windows Mobile Standard devices. The most recent version is Mobile 6.1 with 6.5 available later in 2009. It is rumored that this latest upgrade will be associated with mobile "*cloud computing*". Microsoft created My Phone which is a free service to back up phone information to the cloud for Mobile 6 and higher OSs. Like Android, BlackBerry and the iPhone Microsoft has created a Windows Marketplace for Mobile to encourage developers to create attractive applications for their OS.[52-53] Examples of phones that use this OS are Motorola Q9h, Samsung SCH-i760, HTC Touch Pro, Motorola MC7090 and Palm Treo Pro.

Specs	Android (3G)	BlackBerry (Storm)	iPhone 3GS	Palm (Centro)	Palm Pre	Symbian Nokia E71	Windows Samsung Saga
Provider	T-Mobile	Verizon	AT&T	Sprint, AT&T, Verizon	Sprint	AT&T, T-Mobile	Verizon
OS	Android	BB OS	iPhone OS	Palm OS	Web OS	Symbian OS	Windows Mobile 6.1
Screen size	3.25 inches	3.2 inches	3.5 inches	2.2 inches	3.1 inches	2.36 inches	2.6 inches
Screen Resolution	320 x 480	360 x 480	320 x 480	320 x 320	320 x 480	320 x 240	320 x 320
Camera	3.2 MP	3.2 MP	3 MP	1.3 MP	3 MP	3.2 MP	2 MP
Expandable Memory	MicroSD	Micro SD	No	Micro SD	No	Micro SD	Micro SD
WiFi	Yes	No	Yes	No	Yes	Yes	Yes
Bluetooth	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Network	GSM, UMTS	GSM, CDMA, UMTS	GSM, UMTS	CDMA	CDMA	GSM, UMTS	GSM, CDMA
Storage Capacity	4 GB	8 GB	16/32 GB	65 MB	8 GB	115 MB	112 MB
Processor Speed		500 MHz		312 MHz	600 MHz	381 MHz	400 MHz
Touch screen	Yes	Yes	Yes	No	Yes	No	Yes
Price	**$199**	**$199**	**$199-299**	**$99**	**$199**	**$500**	**$199**

Table 9.1 Features of 7 smartphone operating systems

Table 9.2 Smartphone operating system platforms and features

Limitations of mobile technology

Smartphones were not initially intended to replace the PC or laptop, in spite of their impressive evolution. Nevertheless, as computers such as netbooks get smaller and smartphones improve access speed to the Internet and inputting options, there is some convergence. Widespread broadband wireless will also change the utility of smartphones as rapid access to the Internet becomes a reality. Regardless, limitations currently exist for mobile technology:

1. Slow inputting: typical keyboards are too small and inputting with styluses is too slow. Touchscreens are popular but on the slow side. Given the great recent advances in voice recognition performance, it seems likely that this may help solve some of the inputting issues.[54-55]
2. Small screen: traditionally, handheld computers had tiny screens. Several phones like the iPhone have larger screens to make viewing of web pages and documents more reasonable. The iPhone also allows for more rapid scrolling through multiple pages.
3. Security: as smartphones are used to access enterprise or patient level data, better security will need to be standard. Encryption and anti-viral programs for the mobile platform exist.[56-57]
4. Expense: not everyone is willing to pay for a data plan and other bells and whistles associated with smartphones.
5. Adoption: is probably no longer a major issue if 64% of physicians now embrace this technology.[8] It seems likely that most professionals will be using smartphones for professional and personal reasons in the near future.

Key Points

- Handheld technology is moving from Personal Digital Assistants (PDAs) to smartphones or PDA Phones
- Multiple medical software programs are available for mobile platforms that are free, shareware or fee-based
- Drug look-up programs are very fast and intuitive and therefore essential to the average clinician
- Medical calculators are ideal for mobile platforms
- Although handheld computers began with the Palm and later Windows operating systems, medical software programs for the BlackBerry and *i*Phone operating systems are now very popular

Conclusion

Mobile technology continues to improve and gain popularity in the medical profession at an amazing pace. Handheld units are being used for storing medical information, telephonic communication, patient monitoring and clinical decision support. In the not too distant future, they will likely be used commonly for geo-location and connectivity to electronic health records and other hospital networks. Smartphones have replaced most PDAs and continue to improve processer speed, memory and multimedia features. Interest in smartphones will continue to increase also due to more medical and non-medical applications developed and evolving 4 G networks. We believe that voice recognition has improved to the degree that it may become a prominent means of inputting for the smartphone in the not too distant future. Competition among the various operating systems is intense, driving functionality up and cost down.

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10

Evidence Based Medicine

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Learning Objectives:

After reading this chapter the reader should be able to:

- State the definition and origin of evidence based medicine
- Define the benefits and limitations of evidence based medicine
- Describe the evidence pyramid and levels of evidence
- State the process of using evidence based medicine to answer a medical question
- Compare and contrast the most important online and PDA/smartphone evidence based medicine resources

"The great tragedy of Science- the slaying of a beautiful hypothesis by an ugly fact"
Thomas Huxley (1825-1875)

Some might ask why Evidence Based Medicine (EBM) is included in a textbook on Medical Informatics. The reason is that medical performance is based on quality and quality is based on the best available evidence. Clearly, information technology has the potential to improve decision making through online medical resources, electronic clinical practice guidelines, electronic health records (EHRs) with decision support, online literature searches, statistical analysis and online continuing medical education (CME).This chapter is devoted to finding the best available evidence. Although one could argue that EBM is a buzz word like quality, in reality it means that clinicians should seek and apply the highest level of evidence available. According to the Center for Evidence Based Medicine, EBM can be defined as:

> *"the conscientious, explicit and judicious use of current best evidence in making decisions about the care of individual patients"*[1]

In *Crossing the Quality Chasm,* the Institute of Medicine (IOM) states:

> *"Patients should receive care based on the best available scientific knowledge. Care should not vary illogically from clinician to clinician or from place to place"*[2]

What the IOM is saying, is that every effort should be made to find the best answers and that these answers should be standardized and shared among clinicians. Such standardization implies that clinical practice should be consistent with the best available evidence that would apply to the majority of patients. This is easier said than done because so many clinicians are independent practitioners with little allegiance to any one healthcare organization. It is true that many questions cannot be answered by current evidence so clinicians may have to turn to subject experts. It is also true that the medical profession lacks the time and the tools to seek the best evidence. More than 1,800 citations are added to MEDLINE every day, making it impossible for a practicing clinician to stay up-to-date with the medical literature, not to mention that interpreting this evidence requires

certain expertise and knowledge that not every clinician has. One does not have to look very far to see how evidence changes recommendations:

- Bed rest is no longer recommended for low back pain; exercise is recommended[3]
- Bed rest is no longer recommended following a spinal tap (lumbar puncture); routine activity is recommended instead [4]

Until these older recommendations were challenged with high quality randomized controlled trials the medical profession had to rely on expert opinion, best guess or limited research studies.

Three pioneers are closely linked to the development of EBM. Gordon Guyatt coined the term EBM in 1991 in the American College of Physician (ACP) Journal Club.[5] The initial focus of EBM was on clinical epidemiology, methodology and detection of bias. This created the first fundamental principle of EBM: not all evidence is equal; there is a hierarchy of evidence that exists. In the mid 1990's, it was realized that patients' values and preferences are essential in the process of decision making, and addressing these values has become the second fundamental principle of EBM, after the hierarchy of evidence. Archie Cochrane, a British epidemiologist, was another early proponent of EBM. Cochrane Centers and the International Cochrane Collaboration were named after him as a tribute to his early work. The Cochrane Collaboration consists of review groups, centers, fields, methods groups and a consumer network. Review groups, located in 13 countries, look at randomized controlled trials. As of 2005 they have completed about 2000+ systematic reviews, even though there have been 300,000 randomized controlled trials published.[6-7] The rigorous reviews are performed by volunteers, so efforts are slow. David Sackett is another EBM pioneer who has been hugely influential at The Centre for Evidence Based Medicine in Oxford, England and at McMaster University, Ontario, Canada. EBM has also been fostered at McMaster University by Brian Haynes who is the Chairman of the Department of Clinical Epidemiology and Biostatistics and the editor of the American College of Physician's (ACP) Journal Club. Although EBM is popular in the United Kingdom and Canada it has received mixed reviews in the United States. The primary criticisms are that EBM tends to be a very labor intensive process and in spite of the effort, frequently no answer is found.

The first randomized controlled trial was published in 1948.[8] For the first time subjects who received a drug were compared with similar subjects who would receive another drug or placebo and the outcomes were evaluated. Subsequently, studies became "double blinded" meaning that both the investigators and the subjects did not know whether they received an active medication or a placebo. Until the 1980s evidence was summarized in review articles written by experts. However, in the early 1990s, systematic reviews and meta-analyses became known as a better and more rigorous way to summarize the evidence and the preferred way to present the best available evidence to clinicians and policy makers. Since the late 1980s more emphasis has been placed on improved study design and true patient outcomes research. It is no longer adequate to show that a drug reduces blood pressure or cholesterol; it should demonstrate an improvement in patient-important outcomes such as reduced strokes or heart attacks.[9]

Why is EBM Important?

Learning EBM is like climbing a mountain to gain a better view. You might not make it to the top and find the perfect answer but you will undoubtedly have a better vantage point than those who choose to stay at sea level. Reasons for studying EBM resources and tools include:

- Current methods of keeping medically or educationally up to date do not work
- Translation of research into practice is often very slow
- Lack of time and the volume of published material result in information overload

- The pharmaceutical industry bombards clinicians and patients everyday; often with misleading or biased information
- Much of what we consider as the "standard of care" in every day practice has yet to be challenged and could be wrong

Without proper EBM training we will not be able to appraise the best information resulting in poor clinical guidelines and wasted resources.

How have we traditionally gained medical knowledge?

1. **Continuing Medical Education (CME).** Traditional CME is desired by many clinicians but the evidence shows it to be highly ineffective and does not lead to changes in practice. In general, busy clinicians are looking for a non-stressful evening away from their practice or hospital with food and drink provided.[10-11] Much of CME is provided free by pharmaceutical companies with their inherent biases. Better educational methods must be developed. A recent study demonstrated that online CME was at least comparable, if not superior to traditional CME.[12]
2. **Clinical Practice Guidelines (CPGs).** This will be covered in more detail in the next chapter. Unfortunately, just publishing CPGs does not in and of itself change how medicine is practiced and the quality of CPGs is often variable and inconsistent.
3. **Expert advice**. Experts often approach a patient in a significantly different way compared to primary care clinicians because they deal with a highly selective patient population. Patients are often referred to specialists because they are not doing well and have failed treatment. For that reason, expert opinion needs to be evaluated with the knowledge that their recommendations may not be relevant to a primary care population. Expert opinion therefore should complement and not replace EBM.
4. **Reading.** It is clear that most clinicians are unable to keep up with medical journals published in their specialty. Most clinicians can only devote a few hours each week to reading. All too often information comes from pharmaceutical representatives visiting the office. Moreover, recent studies may contradict similar prior studies, leaving clinicians confused as to the best course.

What are the normal EBM steps towards answering a question?

The following are the typical steps a clinician might take to answer a patient-related question:

1. You see a patient and generate a question
2. You next formulate a well constructed question. Here is the PICO method, developed by the National Library of Medicine, to formulate a question:
    a) **P**atient or problem: how do you describe the patient group you are interested in? Elderly? Gender? Diabetic?
    b) **I**ntervention: what is being introduced, a new drug or test?
    c) **C**omparison: with another drug or placebo?
    d) **O**utcome: what are you trying to measure? Mortality? Hospitalizations? A web based PICO tool has been created by the National Library of Medicine to search Medline.[13] This tool can be placed as a short cut on any computer.
    e) It has been recently suggested to add a T to PICO (i.e., PICOT) to indicate the **T**ype of study that would best answer the PICO question.

3. Seek the best evidence for that question via an EBM resource or PubMed
4. Appraise that evidence using tools mentioned in this chapter
5. Apply the evidence to your patient considering patient's values, preferences, and circumstances.[14]

Evidence appraisal:

When evaluating evidence, one needs to assess its validity, results and applicability.

Validity means: is the study believable? If apparent biases or errors in selecting patients, measuring outcomes, conducting the study, or analysis are present, then the study is less valid.

Results should be assessed in terms of the magnitude of treatment effect and precision (narrower confidence intervals or statistically significant results indicate higher precision).

Applicability, also called external validity, indicates that the results reported in the study can be generalized to the patients of interest.

The most common types of clinical questions:

1. Therapy question. This is the most common area for medical questions and the only one we will discuss in this chapter
2. Prognosis question
3. Diagnosis question
4. Harm question
5. Cost question

The Evidence Pyramid

The pyramid in figure 10.1 represents the different types of medical studies and their relative ranking. The starting point for research is often animal studies and the pinnacle of evidence is the meta-analysis of randomized trials. With each step up the pyramid our evidence is of higher quality associated with fewer articles published.[15] Although systematic reviews and meta-analyses are the most rigorous means to evaluate a medical question, they are expensive, labor intensive, and their inferences are limited by the quality of the evidence of the original studies.

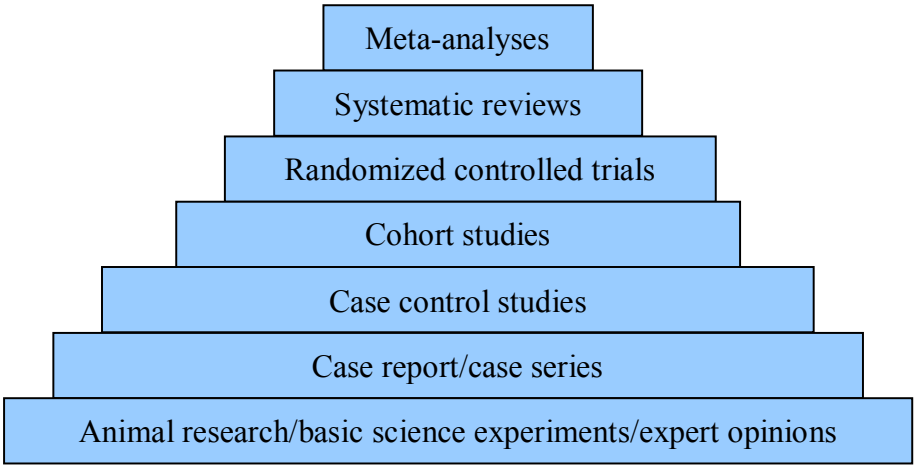

Figure 10.1. The Evidence Pyramid

Case reports/case series. Consist of collections of reports on the treatment of individual patients without control groups, therefore they have much less scientific significance.

Case control studies. Study patients with a specific condition (retrospective or after the fact) and compare with people who do not. These types of studies are often less reliable than randomized controlled trials and cohort studies because showing a statistical relationship does not mean that one factor necessarily caused the other.

Cohort studies. Evaluate (prospectively or followed over time) and follow patients who have a specific exposure or receive a particular treatment over time and compare them with another group that is similar but has not been affected by the exposure being studied. Cohort studies are not as reliable as randomized controlled studies, since the two groups may differ in ways other than the variable under study.

Randomized controlled trials (RCTs). Subjects are randomly assigned to a treatment or a control group that received placebo or no treatment. The randomization assures to a great extent that patients in the two groups are balanced in both known and unknown prognostic factors, and that the only difference between the two groups is the intervention being studied. RCTs are often "double blinded" meaning that both the investigators and the subjects do not know whether they received an active medication or a placebo. This assures that patients and clinicians are less likely to become biased during the conduct of a trial, and the randomization effect remains protected throughout the trial. RCTs are considered the gold standard design to test therapeutic interventions.

Systematic reviews. Defined as protocol-driven comprehensive reproducible searches that aim at answering a focused question; thus, multiple RCTs are evaluated to answer a specific question. Extensive literature searches are conducted (usually by several different researchers to reduce selection bias of references) to identify studies with sound methodology; a very time consuming process. The benefit is that multiple RCTs are analyzed, not just one study.

Meta-analyses. Defined as the quantitative summary of systematic reviews that take the systematic review a step further by using statistical techniques to combine the results of several studies as if they were one large single study.[15] Meta-analyses offer two advantages compared to individual studies. First, they include a larger number of events, leading to more precise (i.e., statistically significant) findings. Second, their results apply to a wider range of patients because the inclusion criteria of systematic reviews are inclusive of criteria of all the included studies.

We will be dealing exclusively with therapy questions so note that randomized controlled trials are the suggested study of choice[16]

Table 10.1 Suggested studies for questions asked

Type of Question	Suggested Best Type of Study
Therapy	RCT > cohort > case control > case series
Diagnosis	Prospective, blind comparison to a gold standard
Harm	RCT + cohort > case control > case series
Prognosis	Cohort study > case control > case series
Cost	Economic analysis and modeling

Evidence of harm should be derived from both designs, RCTs and cohort studies. Cohort studies have certain advantages over RCTs when it comes to assessing harm: larger sample size, longer follow up duration, and more permissive inclusion criteria that allow a wide range of patients representing a real world utilization of the intervention to be included in the study.

Levels of Evidence (LOE)

Several methods have been suggested to grade the quality of evidence, which on occasion, can be confusing. The most up-to-date and acceptable framework is the GRADE (Grading of Recommendations, Assessment, Development and Evaluation).[17] The following is a description of the levels of evidence in this framework:

- Level 1: High quality evidence (usually derived from consistent and methodologically sound RCTs)
- Level 2: Moderate quality evidence (usually derived from inconsistent or less methodologically sound RCTs; or exceptionally strong observational evidence)
- Level 3: Low quality evidence (usually derived from observational studies)
- Level 4: Very low quality evidence (usually derived from flawed observational studies, indirect evidence or expert opinion)

In this framework, RCTs start with a level 1 and observational studies start with a level 3; both can be upgraded or downgraded if they met certain criteria based on their methodology and applicability.

Risk Measures and Terminology

Overall, therapy trials are the most common area of research and ask questions such as, is drug A better than drug B or placebo? In order to determine what the true effect of a study is, it is important to understand the concept of risk reduction and the number needed to treat. These concepts are used in studies that have dichotomous outcomes (i.e., only 2 possible answers such as dead or alive, improved or not improved); which are more commonly utilized outcomes. We will define these concepts and then present an example for illustration.

Risk is defined as the rate of events during a specific period of time. It is calculated by dividing the number of patients suffering events by the total number of patients at risk for events.

Odds are defined as the ratio of the number of patients with events to the number of patients without events.

Notice that $Odds=1/(1+risk)$

Consider this example; Amazingstatin is a drug that lowers cholesterol. If we treat a 100 patients with this drug and 5 of them suffer a heart attack over a period of 12 months, the risk of having a heart attack in the treated group would be 5/100= 0.050 (or 5%). The odds of having a heart attack would be 5/95= 0.052. In the control group, if we treat 100 patients with placebo and 7 suffer heart attacks, the risk in this group is 7/100=0.070 or 7% and the odds are 7/93=0.075.
Notice that the risk in the experimental group is called experimental event rate (EER) and the risk in the control group is called control event rate (CER).

To compare risk in 2 groups, we use the following terms:

Relative Risk (RR) is the ratio of 2 risks as defined above. Thus, it is the ratio of the event rate of the outcome in the experimental group (EER) to the event rate in the control group (CER).
RR = EER/CER.

Relative Risk Reduction (RRR) is the difference between the experimental event rate (EER) and the control event rate (CER), expressed as a percentage of the control event rate.

RRR = (EER-CER)/CER.

Absolute Risk Reduction (ARR) is the difference between the EER and the CER.

ARR = EER-CER

Number Needed to Treat (NNT) is the number of patients who have to receive the intervention to prevent one adverse outcome.[18]

NNT = 1/ARR (or 100/ARR, if ARR is expressed as a percentage instead of a fraction)

Odds ratio (OR) is the ratio of odds (instead of risk) of the outcome occurring in the intervention group to the odds of the outcome in the control group.

Consider the example of Amazingstatin:

- On Amazingstatin, 5% (EER) of patients have a heart attack after 12 months of treatment. On placebo 7% (CER) of patients have a heart attack over 12 months
- RR = 5% /7% = 0.71
- RRR = (7% - 5%) /7% = 29%
- ARR = 7% - 5% = 2%
- NNT = 100/2 = 50
- As we calculated above, the odds for the intervention and control group respectively are 0.052 and 0.075; the odds ratio (OR)=0.52/0.075=0.69

Comments:

- RR and OR are very similar concepts and as long as the event rate is low, their results are almost identical
- These results show that this drug cuts the risk of heart attacks by 29% (almost by a third), which seems like an impressive effect. However, the absolute reduction in risk is only 2% and we need to treat 50 patients to prevent one adverse event. Although this NNT may be acceptable, using RRR seems to exaggerate our impression of risk reduction compared with ARR. Most of what we see written in the medical literature and the lay press will quote the RRR. Unfortunately, very few studies offer NNT data, but it is very easy to calculate if you know the ARR specific to your patient. Nuovo, et al noted that NNT data was infrequently reported by five of the top medical journals in spite of being recommended[19]
- In another interesting article, Lacy and co-authors studied the willingness of US and UK physicians to treat a medical condition based on the way data was presented. Ironically, the data was actually the same but presented in three different ways. Table 10.2 suggests that US physicians may need more training in EBM[20]

Table 10.2 Physician's Likelihood of Prescribing Medicaion Based on How Research Data is Presented

Physicians From	Relative Risk Reduction (RRR)	Absolute Risk Reduction (ARR)	Number Needed To Treat (NNT)
United States	54%	4%	10%
United Kingdom	24%	11%	22%

Examples of using RRR, ARR and NNT. A full page article appeared in a December 2005 Washington Post newspaper touting the almost 50% reduction of strokes by a cholesterol lowering drug. This presented an opportunity to take a look at how drug companies usually advertise the benefits of their drugs. Firstly, in small print, you note that patients have to be diabetic with one other risk factor for heart disease to see benefit. Secondly, there are no references. The statistics are derived from the CARDS Study published in the Lancet in Aug 2004.[21] Stroke was reported to occur in 2.8% in patients on a placebo and 1.5% in patients taking the drug Lipitor. The NNT is therefore 100/1.3 or 77. So, you had to treat 77 patients for an average of 3.9 years (the average length of the trial) to prevent one stroke. This doesn't sound as good as "cuts the risk by nearly half". Now armed with these EBM tools, look further the next time you read about a miraculous drug effect.

Number needed to harm (NNH) is calculated similarly to the NNT. If, for example, Amazingstatin was associated with intestinal bleeding in 6% of patients compared to 3% on placebo, the NNH is calculated by dividing the ARR (%) into 100. For our example the calculation is 100/.03 = 33. In other words, the treatment of 33 patients with Amazingstatin for one year resulted, on average, in one case of intestinal bleeding as a result of the treatment. Unlike NNT, the higher the NNH, the better.

Cost of preventing an event (COPE). Many people reviewing a medical article would want to know what the cost of the intervention is. A simple formula exists that sheds some light on the cost: COPE = NNT x number of years treated x 365 days x the daily cost of the treatment. Using our example of Amazingstatin = 40 x 1 x 365 x $2 or $29,200 to treat 40 patients for one year to prevent one heart attack. Now you can compare COPE scores with other similar treatments.[22]

Limitations of the Medical Literature and EBM

Because evidence is based on information published in the medical literature, it is important to point out some of the limitations researchers and clinicians must deal with on a regular basis:

- There is a low yield of clinically useful articles in general[23]
- There are frequent conflicts of interest as a result of pharmaceutical company influence on research[24-26]
- Conclusions from randomized drug trials tend to be more positive if they are from for-profit organizations[27]
- Up to 16% of well publicized articles are contradicted in subsequent studies[28]
- Peer reviewers are "unpaid, anonymous and unaccountable" so it is often not known who reviewed an article and how rigorous the review was[29]
- Many medical studies are poorly designed[30]

- The recruitment process was not described[31]
- Many randomized trials (particularly drug company sponsored trials) are stopped prematurely due to early benefit. It is possible that benefit would not be seen in a longer study[32]
- Inadequate power (size) to make accurate conclusions. In other words, not enough subjects were studied[33]
- Studies with negative results (i.e., results that are not statistically significant) are not always published or take more time to be published, resulting in "publication bias". In an effort to prevent this type of bias the American Medical Association advocates mandatory registration of all clinical trials in public registries. Also, the International Committee of Medical Journal Editors requires registration as a condition to publish in one of their journals. However, they do not require publishing the results in the registry at this time. Registries could be a data warehouse for future mining and some of the well known registries include:
  - ClinicalTrials.gov
  - WHO International Clinical Trials Registry
  - Global Trial Bank of the American Medical Informatics Association
  - Trial Bank Project of the University of California, San Francisco[34]

In spite of the fact that EBM is considered a highly academic process towards gaining medical truth, numerous problems exist:

- Different evidence rating systems by various medical organizations
- Different conclusions by experts evaluating the same study
- Time intensive exercise to evaluate existing evidence
- Systematic reviews are limited in the topics reviewed (3000 in the Cochrane database) and are time intensive to complete (6-24 months). Often the conclusion is that current evidence is weak and further high quality studies are necessary
- Randomized controlled trials are expensive. Drug companies tend to fund only studies that help a current non-generic drug they would like to promote
- Results may not be applicable to every patient population
- Some view EBM as "cookbook medicine"[35]
- There is not good evidence that teaching EBM changes behavior[36]

Other Approaches

EBM has had both strong advocates and skeptics since its inception. One of its strongest proponents, Dr David Sackett published his experience with an "Evidence Cart" on inpatient rounds in 1998. The cart contained numerous EBM references but was so bulky that it could not be taken into patient rooms.[37] Since that article, multiple, more convenient EBM solutions exist. While there are those EBM advocates who would suggest we use solely EBM resources, many others feel that EBM "may have set standards that are untenable for practicing physicians".[38-39]

Dr Frank Davidoff believes that most clinicians are too busy to perform literature searches for the best evidence. He believes that we need "Informationists", who are experts at retrieving information.[40] To date, only clinical medical librarians (CMLs) have the formal training to take on this role. At large academic centers CMLs join the medical team on inpatient rounds and attach pertinent and filtered articles to the chart. As an example, Vanderbilt's Eskind Library has a Clinical Informatics Consult Service.[41-42] The obvious drawback is that CMLs are only available at large medical centers and are unlikely to research outpatient questions.

According to Slawson and Shaughnessy you must become an "information master" to sort through the "information jungle". They define the usefulness of medical information as:

$$\textbf{Usefulness} = \frac{\textit{Validity} \times \textit{Relevance}}{\textit{Work}}$$

Only the clinician can determine if the article is relevant to his/her patient population and if the work to retrieve the information is worthwhile. Slawson and Shaughnessy also developed the notion of looking for "patient oriented evidence that matters" (POEM) and not "disease oriented evidence that matters" (DOEM). POEMS look at mortality, morbidity and quality of life whereas DOEMS tend to look at laboratory or experimental results. They point out that it is more important to know that a drug reduces heart attacks or deaths from heart attacks, rather than just reducing cholesterol levels (DOEM). [43] This school of thought also recommends that you not read medical articles blindly each week but should instead learn how to search for patient specific answers using EBM resources.[44] This also implies that you are highly motivated to pursue an answer, have adequate time and have the appropriate training.

EBM Resources

There are many first-rate online medical resources that provide EBM type answers. They are all well referenced, current and written by subject experts. Several include the level of evidence (LOE). These resources can be classified as **filtered** (an expert has appraised and selected the best evidence, e.g., Up-to-date) or **unfiltered** (non selected evidence, e.g., PubMed). For the EBM purist, the following are considered traditional or classic EBM resources:

- Clinical Evidence[45]
    - British Medical Journal product with two issues per year
    - New drug safety alert section
    - New "latest research" results section
    - Evidence is oriented towards patient outcomes (POEMS)
    - Very evidence based with single page summaries and links to national guidelines
    - Available in paperback (Concise), CD-ROM, online or PDA format
- Cochrane Library[46]
    - Database of systematic reviews. Each review answers a clinical question
    - Database of review abstracts of effectiveness (DARE)
    - Controlled Trials Register
    - Methodology reviews and register
    - Fee-based
- Cochrane Reviews[47]
    - Part of the Cochrane Collaboration
    - Reviews can be accessed for a fee but abstracts are free. A search for low back pain, as an example, returned 44 reviews (abstracts)
- EvidenceUpdates[48]
    - Since 2002 BMJ Updates has been filtering all of the major medical literature. Articles are not posted until they has been reviewed for newsworthiness and relevance; not strict EBM guidelines

  - You can go to their site and do a search or you can choose to have article abstracts e-mailed to you on a regular basis
  - These same updates are available through www.Medscape.com

- ACP Journal Club[49]
  - Bimonthly journal that can be accessed from OVID or free if a member of the American College of Physicians (ACP)
  - Over 100 journals are reviewed but very few articles make the cut: in 1992 only 13% of articles from the NEJM made the Journal Club, all other journals were much lower

- Practical Pointers for Primary Care[50]
  - Free online review of articles written in the New England Journal of Medicine, Journal of the American Medical Journal, British Medical Journal, the Lancet, the Annals of Internal Medicine and the Archives of Internal Medicine
  - Program can be accessed via the web or monthly reports e-mailed to those who subscribe
  - Editor dissects the study and makes summary comments that are very helpful to the reader

- Evidence-Based On-Call[51]
  - User friendly site intended for quick look-ups for clinicians on call
  - Has multiple critically appraised topics (CATs) that point out the most important clinical pearls, with level of evidence

- PDA EBM Resources
  - Centre for EBM www.cebm.utoronto.ca
  - Duke Medical Center Library www.mclibrary.duke.edu/training/pdaformat/
  - EBM 2 go http://www.ebm2go.com

- Others
  - TRIP Database[52]
  - OVID has the ability to search the Cochrane Database of Systematic Reviews, DARE, ACP Journal Club and Cochrane Controlled Trials Register at the same time. Also includes Evidence-Based Medicine Reviews[53]
  - SUMSearch. Free site that searches Medline, National Guideline Clearing House and DARE[54]
  - Bandolier. Free online EBM journal; used mainly by primary care docs in England. Provides simple summaries with NNTs. Resource also includes multiple monographs on EBM that are easy to read and understand[55]
  - Denison Memorial Library: Evidence Based Medicine Resources with extensive links located on the same page[56]

Key Points

- Evidence Based Medicine (EBM) is the academic pursuit of the best available answer to a clinical question
- The two fundamental principles of EBM are: 1) a hierarchy of evidence exists (i.e., not all the evidence is equal), and 2) evidence alone is insufficient for medical decision making. It should rather be complemented by patient's values, preferences and circumstances
- Medical Informatics will hopefully improve medical quality, which is primarily based on EBM
- There are multiple limitations of both EBM and the medical literature
- The average clinician should have a basic understanding of EBM and know how to find answers using EBM resources

Conclusion

Knowledge of evidence based medicine is important if you are involved with patient care, quality of care issues or research. Rapid access to a variety of online EBM resources has changed how we practice medicine. In spite of its shortcomings, an evidence based approach helps healthcare workers find the best possible answers. Busy clinicians are likely to choose commercial high quality resources, while academic clinicians are likely to select true EBM resources. Ultimately, EBM tools and resources will be integrated into all electronic health records as clinical decision tools.

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11

Clinical Practice Guidelines

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M. HASSAN MURAD

Learning Objectives

After reading this chapter the reader should be able to:

- Define the utility of clinical practice guidelines
- Describe the interrelationship between clinical practice guidelines, evidence based medicine, electronic health records and pay for performance
- Define the processes required to write and implement a clinical practice guideline
- Compare and contrast the potential benefits and obstacles of clinical practice guidelines
- Describe clinical practice guidelines in an electronic format
- List the most significant clinical practice guideline resources

The following is a definition of Clinical Practice Guidelines (CPGs):

"A set of systematically developed statements or recommendations designed to assist practitioner and patient decisions about appropriate health care for specific clinical circumstances"[1]

Clinical practice guidelines (CPGs) take the very best evidence based medical information and formulate a game plan to treat a specific disease or condition. If one considers evidence as a continuum that starts by data generated from a single study, appraised and synthesized in a systematic review, CPGs would represent the next logical step in which evidence is transformed into a recommendation. Many medical organizations use CPGs with the intent to improve quality of care, patient safety and/or reduce costs. Information technology assists CPGs by expediting the search for the best evidence and linking the results to EHRs, PDAs and smartphones for easy access. Two areas in which CPGs may be potentially beneficial include disease management (chapter 12 and pay for performance (chapter 13)

- It is important to note that:
    - 83% of Medicare beneficiaries have at least one chronic condition and 68% of Medicare's budget is devoted to the 23% who have 5 or more chronic conditions[2]
    - There is some evidence that guidelines that address multiple co-morbidities (associated illnesses) actually do work. As an example, in one study of diabetics, there was a 50% decrease in cardiovascular and microvascular complications with intensive treatment of multiple risk factors[3]

In spite of evidence to suggest benefit, several studies have shown poor CPG compliance by patients and physicians. The well publicized 2003 RAND study in the New England Journal of Medicine demonstrated that "*overall, patients received 54% of recommended care*".[4-5] In another study of guidelines at a major teaching hospital there was overuse of statin therapy (cholesterol

lowering drugs). Overuse occurred in 69% of cases of primary prevention (to prevent a disease) and 47% overuse in secondary prevention (to prevent disease recurrence), compared to national recommendations.[6]

It should be emphasized that creating or importing a guideline is the easy part because hundreds have already been creating by a variety of national organizations. Implementing CPGs and achieving buy-in by all healthcare workers, particularly physicians, is the hard part.

How are CPGs developed?

Ideally, the process starts with a panel of experts commissioned by a professional organization. The first kind of experts a panel should include is multi-disciplinary content experts (e.g., if the guideline is about preventing venous thrombosis and pulmonary embolism, content experts would be pulmonologists, hematologists, pharmacists and hospitalists).

The second kind of experts are methodology experts (experts in evidence based medicine, epidemiology, statistics, cost analysis, etc.). The panel refines the questions (usually in PICO format). A systematic literature search and evidence synthesis takes place. Evidence is graded and recommendations are negotiated. Panel members have their own biases and conflicts of interest that should be declared to CPG users. Voting is often needed to build consensus since disagreement is a natural phenomenon in this context.

The Strength of Recommendations

Guideline panels usually associate their recommendations by a grading that describes how confident they are in their statement. Ideally, panels should separately describe their confidence in the evidence (the quality of evidence, described in chapter 10) from the strength of the recommendation. The reason for this separation is that there are factors other than evidence that may affect the strength of recommendation. These factors are: 1) how closely balanced are the benefits and harms of the recommended intervention, 2) patients' values and preferences, and 3) resource allocation.

For example, even if we have very high quality evidence from randomized trials showing that warfarin (a blood thinner) decreases the risk of stroke in some patients, the panel may issue a weak recommendation considering that the harms associated with this medicine are substantial. Similarly, if high quality evidence suggests that a treatment is very beneficial, but this treatment is very expensive and only available in very few large academic centers in the US, the panel may issue a weak recommendation because this treatment is not easily available or accessible.

Application to Individuals

A physician should consider a strong recommendation to be applicable to all patients who are able to receive it. Therefore, the physician should spend his/her time and effort on explaining to patients how to use the recommended intervention and integrate it in their daily routine.

On the other hand, a weak recommendation may only apply to certain patients. Physicians should spend more time on discussing pros and cons of the intervention with patients, use risk calculators and tools designed to stratify patients' risk to better determine the balance of harms and benefit for the individual. Weak recommendations are the optimal condition to use decision aids, which are available in written, videographic and electronic formats and may help in the decision-making process by increasing knowledge acquisition by patients and reduce their anxiety and decisional conflicts.

Appraisal and Validity of Guidelines

There are several tools suggested to appraise CPGs and determine their validity. These tools assess the process of conducting CPGs, the quality and rigor of the recommendations and the clarity of their presentation. The following list includes some of the attributes that guidelines users (clinicians, patients, policy makers) should seek to determine if a particular CPG is valid and has acceptable quality:

- Evidence based, preferably linked to systematic reviews of the literature
- Considers all relevant patients groups and management options
- Considers patient-important outcomes (as opposed to surrogate outcomes)
- Updated frequently
- Clarity and transparency in describing the process of CPGs development (e.g., voting, etc.)
- Clarity and transparency in describing the conflicts of interests of the guideline panel
- Addresses patients' values and preferences
- Level of evidence and strength of recommendation are given
- Simple summary or algorithm that is easy to understand
- Available in multiple formats (print, online, PDA, etc.) and in multiple locations
- Compatibility with existing practices
- Simplifies, not complicates decision making[7]

Barriers to CPGs

- Practice setting: inadequate incentives, inadequate time and fear of liability. A 2003 study estimated that it would require 7.4 hours/working day just to comply with all of the US Preventive Services Task Force recommendations for the average clinician's practice![8]
- Contrary opinions: local experts do not always agree with CPG or clinicians hear different message from drug detail representative
- Sparse data: there are several medical areas in which the evidence is of lower quality or sparse. Guideline panels in these areas would heavily depend on their expertise and should issue weak recommendations (e.g. suggestions) or no recommendations if they did not reach a consensus. These areas are problematic to patients and physicians and are clearly not ready for quality improvement projects or pay for performance incentives. For years, diabetologists advocated tight glycemic control of patients with type 2 diabetes; however, it turned out from results of recent large randomized trials that this strategy is inaccurate[9]
- Knowledge and attitudes: there is a lack of confidence to either not perform a test (malpractice concern) or to order a new treatment (don't know enough yet). Information overload is always a problem[10]
- CPGs can be too long, impractical or confusing. One study of Family Physicians stated CPGs should be no longer than 2 pages.[11-12] Most national CPGs are 50-150 pages long and don't always include a summary of recommendations
- Where and how do you post CPGs? What should be the format?
- Less buy-in if datat reported is not local since physicians tend to respond to data reported from their hospital or clinic
- No uniform level of evidence (LOE) rating system

- Too many CPGs posted on the National Guideline Clearinghouse. For instance, a non-filtered search in January 2009 by one author for "diabetes" yielded 535 diabetes-related CPGs. The detailed search option helps filter the search but is not very user friendly[13]
- Lack of available local champions to promote CPGs
- Excessive influence by drug companies: Survey of 192 authors of 44 CPGs 1991-1999
    - 87% had some tie to drug companies
    - 58% received financial support
    - 59% represented drugs mentioned in the CPG
    - 55% of respondents with ties to drug companies said they did not believe they had to disclose involvement[14]
- National Guidelines are not necessarily of high quality. A 2009 review of CPGs from the American Heart Association and the American College of Cardiology (1984-Sept 2008) concluded that many of the recommendations were based on a lower level of evidence or expert opinion, not high quality studies[15]
- At this point patients are not normally involved in any aspect of CPGs, even though they receive recommendations based on CPGs. In an interesting 2008 study, patients who received an electronic message about guidelines experienced a 12.8% increase in compliance. This study utilized claims data as well as a robust rules engine to analyze patient data. Patients received alerts (usually mail) about the need for screening, diagnostic and monitoring tests. The most common alerts were for adding a cholesterol lowering drug, screening women over age 65 for osteoporosis, doing eye exams in diabetics, adding an ACE inhibitor drug for diabetes and testing diabetics for urine microalbumin.[16] It makes good sense that patients should be knowledgeable about national recommendations and should have these guidelines available in multiple formats. Also, because many patients are highly "connected" they could receive messages via cell phones, social networking software, etc to improve monitoring and treatment

Where should Hospitals or Individuals start? Examples:

- High cost conditions: heart failure
- High volume conditions: diabetes
- Preventable admissions: asthmatics
- Where you suspect you have variation in care compared to national recommendations: deep vein thrombophlebitis (DVT) prevention
- High litigation areas: failure to diagnose or treat
- Pressing patient safety areas: intravenous (IV) drug monitoring

The Strategy

- Leadership support is crucial
- Use process improvement tools such as the Plan-Do-Study-Act (PDSA) model
- Identify gaps in knowledge between national recommendations and local practice
- Locate a guideline champion who is a well respected clinician expert.[17] A champion acts as an advocate for implementation based on his/her support of a new guideline
- Other potential team members
    - Clinician selection based on the nature of the CPG
    - Administrative or support staff

  - Quality Management staff
- Develop action plans
- Educate all staff involved with CPGs, not just clinicians
- Pilot implementation
- Provide frequent feedback to clinicians and other staff regarding results

Examples of Clinical Practice Guidelines

The CPG in figure 11.1 was written for the treatment of uncomplicated bladder infections (cystitis) in women. The goal was to use less expensive antibiotics and for fewer days. The protocol or algorithm can be administered by a triage nurse when a patient telephones or walks in. Figure 11.2 demonstrates that the use of the first line drug (sulfa family) increased after the start of the CPG, whereas second line drug use decreased. Success of this program was based on educating all members of the healthcare team and reporting the results at medical staff meetings and other venues. It was also aided by an easy to follow guideline and full support by the nursing staff

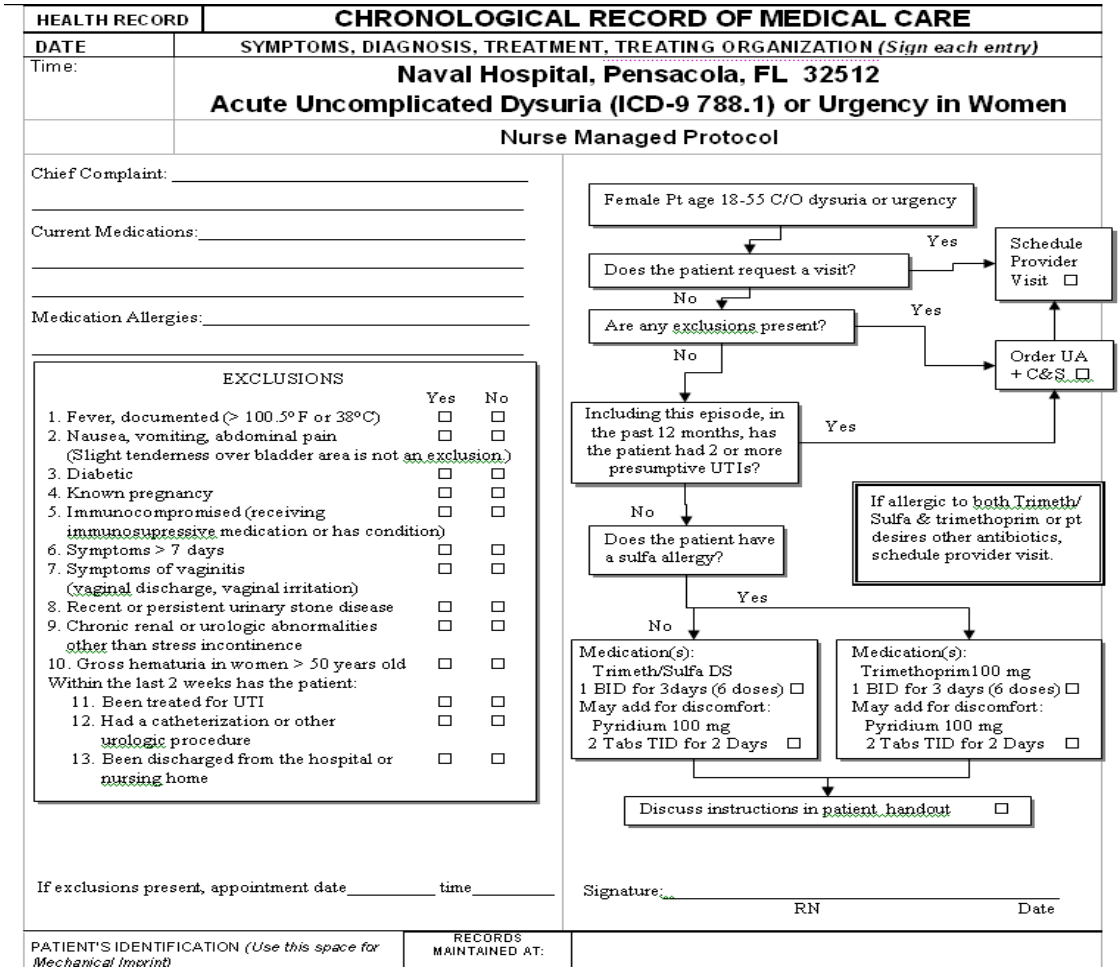

HEALTH RECORD
CHRONOLOGICAL RECORD OF MEDICAL CARE
DATE
SYMPTOMS, DIAGNOSIS, TREATMENT, TREATING ORGANIZATION (Sign each entry)
Time:
Naval Hospital, Pensacola, FL 32512
Acute Uncomplicated Dysuria (ICD-9 788.1) or Urgency in Women
Nurse Managed Protocol
Chief Complaint:
Current Medications:
Medication Allergies:
EXCLUSIONS
Yes No
1. Fever, documented (> 100.5º F or 38ºC)
2. Nausea, vomiting, abdominal pain
(Slight tenderness over bladder area is not an exclusion.)
3. Diabetic
4. Known pregnancy
5. Immunocompromised (receiving immunosupressive medication or has condition)
6. Symptoms > 7 days
7. Symptoms of vaginitis
(vaginal discharge, vaginal irritation)
8. Recent or persistent urinary stone disease
9. Chronic renal or urologic abnormalities other than stress incontinence
10. Gross hematuria in women > 50 years old
Within the last 2 weeks has the patient:
11. Been treated for UTI
12. Had a catheterization or other urologic procedure
13. Been discharged from the hospital or nursing home
If exclusions present, appointment date_____ time_____
Female Pt age 18-55 C/O dysuria or urgency
Does the patient request a visit?
Yes
Schedule Provider Visit
No
Are any exclusions present?
Yes
Order UA + C&S
No
Including this episode, in the past 12 months, has the patient had 2 or more presumptive UTIs?
Yes
If allergic to both Trimeth/ Sulfa & trimethoprim or pt desires other antibiotics, schedule provider visit.
No
Does the patient have a sulfa allergy?
Yes
No
Medication(s):
Trimeth/Sulfa DS
1 BID for 3days (6 doses)
May add for discomfort:
Pyridium 100 mg
2 Tabs TID for 2 Days
Medication(s):
Trimethoprim100 mg
1 BID for 3 days (6 doses)
May add for discomfort:
Pyridium 100 mg
2 Tabs TID for 2 Days
Discuss instructions in patient handout
Signature:
RN
Date
PATIENT'S IDENTIFICATION (Use this space for Mechanical Imprint)
RECORDS MAINTAINED AT:

Figure 11.1 CPG for uncomplicated dysuria or urgency in women

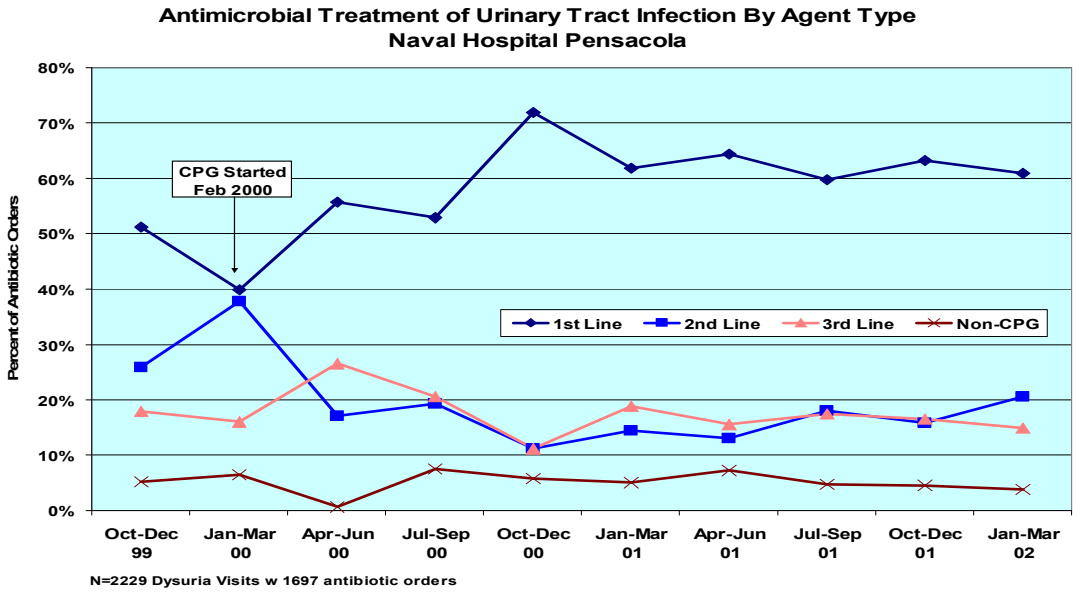


Figure 11.2 Results of CPG implementation (Courtesy Naval Hospital Pensacola)

Clinical Practice Guidelines in electronic format

CPGs have been traditionally paper based and often accompanied by a flow diagram or algorithm. With time, more are being created in an electronic format and posted on the Internet or Intranet for easy access. Zielstorff outlined the issues, obstacles and future prospects of online practice guidelines in a 1998 review.[18] What has changed since then is the ability to integrate CPGs with electronic health records and PDAs/Smartphones.

CPGs on PDAs/Smartphones: These mobile platforms function well in this area as each step in an algorithm is simply a tap or touch of the screen. In addition to commercially hosted PDA/Smartphone programs, CPGs can be created on the PDA or smartphone using iSiloX or MobiPocket Creator (see chapter on Mobile Technology). In figures 11.3 and 11.4 programs are shown that are based on national guidelines for cardiac risk and cardiac clearance. Figure 11.3 depicts a calculator that determines the 10 year risk of heart disease based on serum cholesterol and other risk factors. A cardiac clearance program determines whether a patient needs further cardiac testing prior to an operation (figure 11.4) [19] Many excellent guidelines for the PDA/Smartphone exist that will be listed later in this chapter.

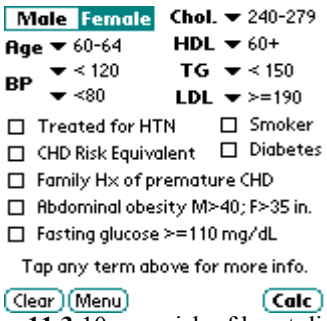


Figure 11.3 10 year risk of heart disease

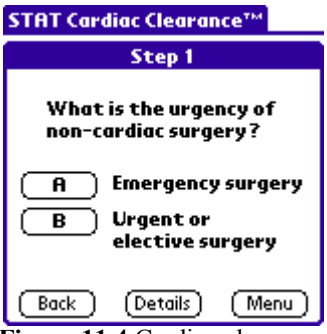


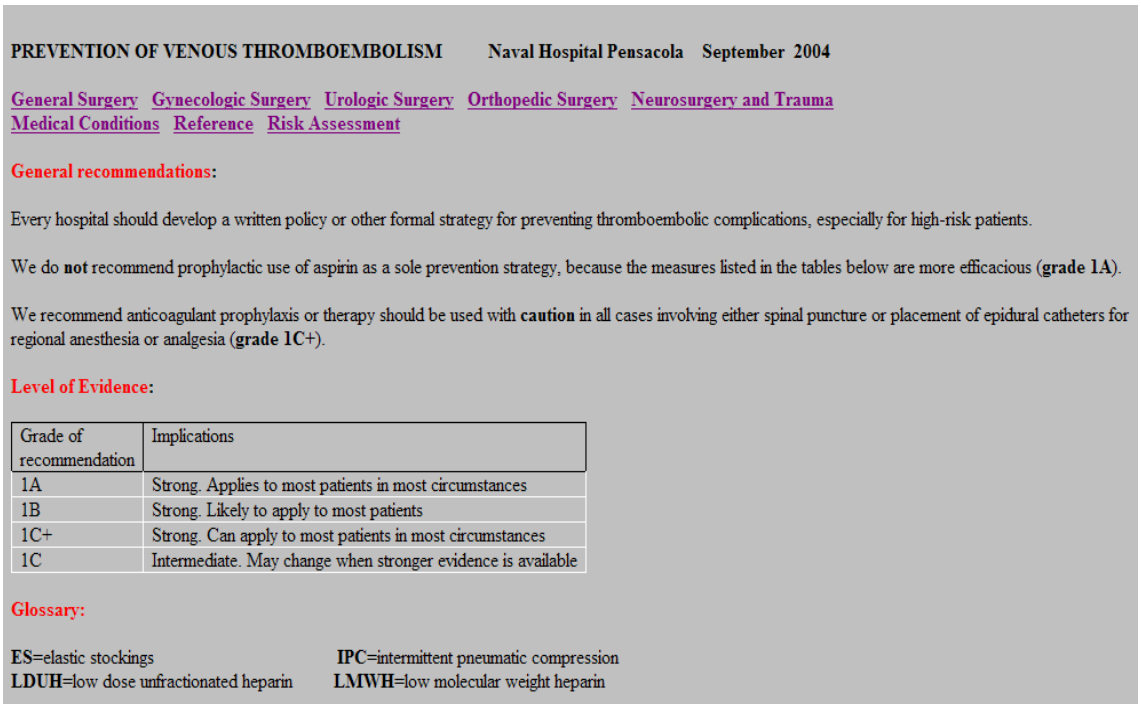
Figure 11.4 Cardiac clearance

Risk Calculators: Many of these are available on a mobile platform and are also available online. While these are not CPGs exactly, they are based on population studies and are felt to be part of EBM and can give direction to the clinician. As an example, some experts feel that aspirin has little benefit in preventing a heart attack unless your 10 year risk of one exceeds 20%. We don't know how many busy clinicians use and understand these valuable tools. The following is a short list of some of the more popular online calculators:

- ATP III Cardiac risk calculator: estimates the 10 year risk of a heart attack or death based on your cholesterol, age, gender, etc. http://hp2010.nhlbihin.net/atpiii/calculator.asp?usertype=prof
- FRAX fracture risk calculator: estimates the 10 year risk of a hip or other fracture based on all of the common risk factors for osteoporosis. Takes into account a patient's bone mineral density score. Takes into account both gender and ethnicity. http://www.shef.ac.uk/FRAX/
- GAIL breast cancer risk assessment tool: estimates a patient's risk of breast cancer, again, based on known and accepted risk factors. http://www.cancer.gov/bcrisktool/
- Stroke risk calculator: based on the Framingham study it predicts 10 year risk of a stroke based on known risk factors. http://www.stroke-education.com/calc/risk_calc.do
- Risk of stroke or death for new onset atrial fibrillation: also based on the Framingham study, it calculates 5 year risk of stroke or death. http://www.zunis.org/FHS%20Afib%20Risk%20Calculator.htm

HTML CPGs: Another simple technique to post a CPG in a user-friendly format is to write it as a Word document but save it as a web page (html). Hyperlinking to other pages or simply "book marking" to information located further down on the same page makes navigation much easier and reduces the size of the CPG. This allows a CPG to be written on a single document that is easy to e-mail or post. The CPG in figure 11.5 is an example of the 2004 American College of Chest Physicians (ACCP) Guideline to prevent venous thromboembolism (blood clots in legs and lungs). Select a hyperlink such as General Surgery and it takes you to another section with specific recommendations, thus making the document compact and easy to navigate. It is also easy to update or correct.

EHR CPGs: Although a minority of electronic health records have embedded CPGs, there is definite interest in providing local or national CPGs at the point of care. CPGs embedded in the EHR are clearly a form of decision support. They can be linked to the diagnosis or the order entry process. In addition, they can be standalone resources available by clicking, for example, an "info-button". The obvious goal of this clinical decision support is to provide treatment reminders for disease states that may include the use of more cost effective drugs. Institutions such as Vanderbilt University have integrated more than 750 CPGs into their EHR by linking the CPGs to ICD-9 codes.[20] The results of embedded CPGs appears to be mixed. In a study by Durieux using computerized decision support reminders, orthopedic surgeons showed improved compliance to guidelines to prevent deep vein thrombophlebitis.[21] On the other hand, three studies by Tierney, failed to demonstrate improved compliance to guidelines using computer reminders for hypertension, heart disease and asthma.[22-24] Clinical decision support, to include order sets is discussed in more detail in the chapters on electronic health records and patient safety.



PREVENTION OF VENOUS THROMBOEMBOLISM **Naval Hospital Pensacola September 2004**

General Surgery Gynecologic Surgery Urologic Surgery Orthopedic Surgery Neurosurgery and Trauma
Medical Conditions Reference Risk Assessment

General recommendations:

Every hospital should develop a written policy or other formal strategy for preventing thromboembolic complications, especially for high-risk patients.

We do **not** recommend prophylactic use of aspirin as a sole prevention strategy, because the measures listed in the tables below are more efficacious (**grade 1A**).

We recommend anticoagulant prophylaxis or therapy should be used with **caution** in all cases involving either spinal puncture or placement of epidural catheters for regional anesthesia or analgesia (**grade 1C+**).

Level of Evidence:

Grade of recommendation	Implications
1A	Strong. Applies to most patients in most circumstances
1B	Strong. Likely to apply to most patients
1C+	Strong. Can apply to most patients in most circumstances
1C	Intermediate. May change when stronger evidence is available

Glossary:

ES=elastic stockings **IPC**=intermittent pneumatic compression
LDUH=low dose unfractionated heparin **LMWH**=low molecular weight heparin

Figure 11.5 DVT prevention CPG (Courtesy Naval Hospital Pensacola)

There are other ways to use electronic tools to promulgate CPGs. In an interesting paper by Javitt, primary care clinicians were sent reminders on outpatient treatment guidelines based only on claims data. Outliers were located by using a rules engine (Care Engine) to compare a patient's care with national guidelines. They were able to show a decrease in hospitalizations and cost as a result of alerts that notified physicians by phone, fax or letter. This demonstrates one additional means of changing physician behavior using CPGs and information technology not linked to the electronic health record.[25] Critics might argue that claims data is not as accurate, robust or current as actual clinical results.

Software is now available (EBM Connect) that can compute compliance with guidelines automatically using administrative data. The program translates guidelines from text to algorithms for 20 disease conditions and therefore would be much more efficient than chart reviews. Keep in mind it will tell you if, for example, LDL cholesterol was ordered, not the actual results [26]

CPG Resources

Web based CPGs

- National Guideline Clearinghouse. This program is an initiative of the Department of Health and Human Services and is the largest and most comprehensive of all CPG resources. Features offered:
    - Includes about 2200 guidelines
    - There is extensive search engine filtering i.e. you can search by year, language, gender, specialty, level of evidence, etc.
    - Abstracts are available as well as links to full text guidelines where available
    - CPG comparison tool
    - Forum for discussion of guidelines
    - Annotated bibliography
    - They link to 17 international CPG resource sites[27]

- National Institute for Health and Clinical Excellence (NICE)
    - Service of the British National Health Service
    - Approximately 100 CPGs are posted and dated
    - A user-friendly short summary is available as well as a lengthy guideline, both in downloadable pdf format
    - Podcasts are available [28]
- Colorado Clinical Guidelines Collaborative
    - Free downloads available for Colorado physicians and members of CCGC
    - They currently have 14 CPGs available
    - Guidelines are in easy to read tables, written in a pdf format
    - References, resources and patient handouts are available [29]

PDA/Smartphone based CPGs

- National Guideline Clearinghouse
    - CPGs for the Palm OS PDA. Word documents are available to download for the Pocket PC OS. Document reader (Apprisor) is necessary for Palm OS [27]
- American Diabetes Association
    - For Palm OS
    - Includes the 2009 treatment CPG for diabetes [30]
- Sites that require free Apprisor software for downloads:[31]
    - American Heart Association
        - For Palm and Pocket PC OS
        - Covers: heart failure, angioplasty/stents, ventricular arrhythmias, stable and unstable angina, myocardial infarction, bypass surgery, atrial fibrillation, echocardiography, pacemakers, stroke and other preventative guidelines
    - American College of Chest Physicians
        - Covers: lung cancer, emphysema, ventilator related pneumonia, weaning from the ventilator, blood clots, cough and pulmonary rehabilitation
    - Colorado Clinical Guideline Collaborative
        - Covers colorectal cancer screening, diabetes and major depression
    - National Heart, Lung and Blood Institute
        - Covers the JNC VII guide for the treatment of hypertension and the national guidelines for the treatment of cholesterol
    - American College of Physicians
        - Covers: emphysema treatment, ICD-9 codes, bioterrorism and chemical terrorism
    - American Academy of Family Physicians
        - Covers their recommendations for preventive testing
- Centers for Disease Control (CDC)
    - Palm OS only
    - Guideline is for the treatment of sexually transmitted diseases [32]

Key Points

- Clinical Practice Guidelines (CPGs), based on evidence based medicine, are the roadmap to standardize medical care
- CPGs are valuable for chronic disease management or as a means to measure quality of care
- CPGs can be part of electronic health records and order sets
- CPGs can be installed on PDAs or PDA phones
- CPGs can be digital or paper based
- Hundreds of CPGs are readily available for download from many excellent sites

Conclusion

The jury is out regarding the impact of CPGs on physician behavior or patient outcomes. Busy clinicians are slow to accept new information, including CPGs. Whether embedding CPGs into EHRs will result in significant changes in behavior that will consistently result in improved quality, patient safety or cost savings remains to be seen. It is also unknown if linking CPGs to better reimbursement (pay for performance) will result in a higher level of acceptance. While we are determining how to optimally improve healthcare with CPGs, most authorities agree that CPGs need to be concise, practical and accessible at the point of care. Every attempt should be made to make them electronic and integrated into the workflow of clinicians. Moreover, further research is needed to determine if patients consistently benefit from having CPGs customized for patients as well as electronic alerting mechanisms.

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12

Disease Management and Disease Registries

ROBERT E HOYT

Learning Objectives

After reading this chapter the reader should be able to:

- Define the role of disease management in chronic disease
- Describe the need for rapid retrieval of patient and population statistics to manage patients with chronic diseases
- Compare and contrast the various disease registry formats including those that integrate with electronic health records
- Describe the interrelationships between disease registries, evidence based medicine and pay for performance

According to Epstein, Disease Management (DM) is:

> *"a systematic population based approach to identify persons at risk, intervene with a specific program of care and measure clinical and other outcomes "*[1]

Disease Management Programs (DMPs) are important, as pointed out by the Institute of Medicine because:

> *"The current delivery system responds primarily to acute and urgent health care problems. Those with chronic conditions are better served by a systematic approach that emphasizes self management, care planning with a multidisciplinary team and ongoing assessment and follow up"*[2]

DM is generally considered part of Population Health and is divided into the following categories:

- **Disease management**: focuses on specific diseases like diabetes
- **Lifestyle management**: focuses on personal risk factors like smoking
- **Demand management**: focuses on improved utilization, as an example, emergency room usage
- **Condition management:** focuses on temporary conditions such as pregnancy and not diseases

Disease Management is discussed under Medical Informatics because it is dependent on information technology for several processes:

- Automated data collection and analysis
- Clinical Practice Guidelines (CPGs) that are web based or embedded into the electronic health records (EHRs)
- Automated disease registries
- Telemonitoring of patients at home

- Patient tracking
- Web based portals
- Networks to connect multiple healthcare workers on the DM team

In the future, CPGs, EBM programs and DMPs will be embedded or linked within all EHRs. Quality reports will be generated from electronic health records and health information organization and shared with pay for performance programs, researchers, insurers and healthcare organizations.

DMPs were created in part because health maintenance organizations (HMOs) wanted to control the rising cost of chronic diseases. The first DMP was established in the 1980s at Group Health of Puget Sound and Lovelace Health System in New Mexico and now are part of many large health care organizations. As an example, in a survey of over 1000 healthcare organizations, disease registries were established with the following frequencies: diabetes (40.3%), asthma (31.2 %), heart failure (34.8 %) and depression (15.7 %).[3]

Disease management is interrelated to many other topics and chapters in this book, as depicted in Figure 12.1.

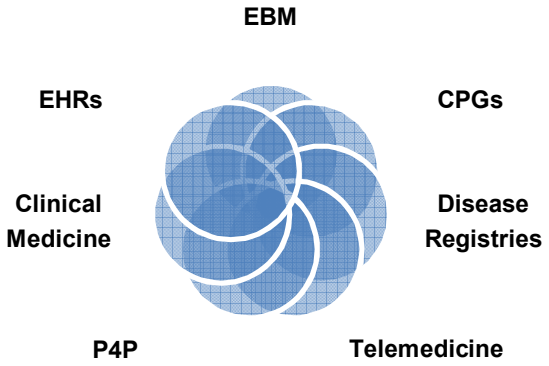

Figure 12.1. Interrelationships between disease management, evidence based medicine (EBM), clinical medicine, pay for performance (P4P), electronic health records (EHRs), clinical practice guidelines (CPGs) and telemedicine

New attention may be paid to DMPs if pay for performance (P4P) (discussed in next chapter) becomes a reimbursement standard. Chronic diseases affect about 20% of the general population and account for 75% of health care spending. By the year 2030, 20% of the US population will be 65 or older. Chronic diseases are more likely to affect lower income populations who have limited access to medical care. Figure 12.2 shows the predicted prevalence of chronic disease in the future.[4]

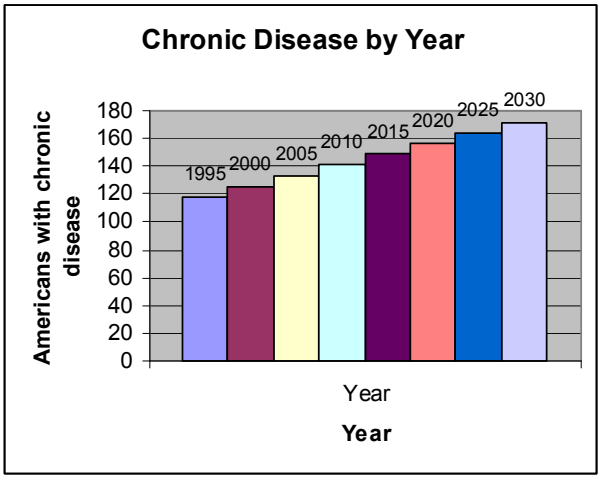

Figure 12.2. Predicted chronic disease prevalence (millions) by year

The most common chronic diseases to be managed are heart failure, diabetes and asthma due to high prevalence and cost. Following close behind are obesity, hypertension, chronic renal failure and chronic obstructive lung disease (COPD).

Disease Management programs involve multiple players:

- Quality Improvement Organizations (QIOs)
- State and Federal Governments (Medicare and Medicaid)
- Pharmacy organizations
- Pharmaceutical companies
- Hospital Systems, including information technology
- Physicians and their office staff
- Employers
- Insurers
- Independent vendors; including EHR vendors
- Health Maintenance Organizations (HMOs)

The integration of multiple players is best demonstrated by the classic *Chronic Care Model* created by Dr E. Wagner and the Macoll Institute for Healthcare Innovation. His model incorporates community resources, healthcare systems, information technology, patient participation and a disease management team.[5]

The usual processes involved in Disease Management are:

- Identification of a problem and a target population
- Comparison of local to national data (how do we compare to others?)
- Review of existing clinical practice guidelines to see if they can be used or modified
- Evaluation of patient self-management education
- Evaluation of process and outcomes measurements
- Feedback to clinicians and other hospital workers
- Emphasize systems and populations, not individuals
- Coordination among multiple services and agencies

Prior to initiating a DM Program the following questions should be addressed:

- What is the goal? Decrease diabetic complications? Decrease trips to the emergency room by asthmatics?
- What population will be studied? Rural and urban? Insured and uninsured?
- Is the problem high volume or high cost or both?
- Are there preventable complications such as hospital admissions?
- How prevalent is the disease? Common enough to create a DMP?
- Are there practice variations among different medical groups?
- Are payers (insurance companies) interested?
- Do guidelines already exist or will a new one need to be created?
- Is the treatment feasible or practical?
- Are outcomes clearly defined, measurable and meaningful?
- Do Information systems already exist for the program? Data retrieval is easier if systems are already in place

The goal of all DMPs is to improve patient outcomes: clinical, behavioral, cost, patient functional status and quality of life.

Centers for Medicare and Medicaid's (CMS) position. Medicare and Medicaid accounts for about one third of national health expenditures so those programs are constantly looking for ways to improve quality and reduce costs. In 2009 Medicare expenditures will be more than $400 billion or 20% of all healthcare expenditures.[6] As pointed out in other sections of this book, when CMS speaks, everyone listens because they have a large checkbook. A quote from the CMS web site: "*About 14 percent of Medicare beneficiaries have congestive heart failure but they account for 43 percent of Medicare spending. About 18 percent of Medicare beneficiaries have diabetes, yet they account for 32 percent of Medicare spending. By better managing and coordinating the care of these beneficiaries, the new Medicare initiatives will help reduce health risks, improve quality of life, and provide savings to the program and the beneficiaries".*[7]

CMS has created 10 pilot programs to see if disease management can save the government money over a three year period (phase I). The Chronic Care Improvement Program (part of the Medicare Modernization Act of 2003) is now known as the Medical Health Support Program. Companies involved will not get paid for disease management unless they can show a total savings of 5% compared to a control group. Companies that can demonstrate improved outcomes are asked to participate in phase II and will likely tackle diabetes or heart failure. The companies selected were: American Healthways, XL Health, Health Dialog Services, LifeMasters and McKesson Health Solutions. All participants will need robust information technology to succeed.[7]

The Newest Chronic Disease Model: The Patient-Centered Medical Home (PCMH) This model is based on the relationship between the patient and their primary care physician (PCP). It is up to the PCP and his/her team to manage and coordinate chronic diseases with the goal of keeping the patient healthy and at home. Although the concept has been around since 1967, it was promoted by major Medical Associations in 2007. Since then the concept has been embraced by private insurers [8], Medicare [9] and the Department of Defense.[10] Part of the concept for PCMH is technology support using disease registries, EHRs, personal health records, e-prescribing, patient portals, health information exchanges and telehomecare. In this model, practices would have to handle more walk-ins and same-day appointments. For a review of the topic and more detail we refer you to a 2008 article. [11]

Medicare is recruiting in 2009 for a 3 year Medical Home Demonstration Project. They plan to include 50 urban and rural practices (2000 clinicians) in 8 states. Primary care and a limited list of specialty practices are eligible. There will be two Tiers of practice with Tier II being more rigorous and requiring EHR usage. Medicare will pay $40.40 per member per month for Tier I and $51.70 per member per month for Tier II care, but this is adjusted upwards depending on the level of patient disease severity. More detail is available on the Centers for Medicare/Medicaid web site.[9]

What do we know from current programs and the medical literature?

- A study in the Journal of the American Medical Association (JAMA) demonstrated that 32 of 39 interventions showed improvement in at least one process or outcome measurement for diabetic patients; 18 of 27 studies involving three chronic conditions also demonstrated lower health care costs and/or lower utilization of services [12]
- A comprehensive DMP for African-American diabetics showed large reductions in amputations, hospitalizations, emergency room visits and missed work days with an aggressive foot care program. It should be noted, however, that this was not a randomized controlled trial so results should be interpreted with caution [13]
- HealthPartners Optimal Diabetes Care Impact: Program noted 400 fewer cases of retinopathy (eye damage) each year; 120 fewer amputations each year and 40-80 fewer myocardial infarctions (heart attacks) per year [14]

- A systematic review/meta-analysis of DMPs on heart failure concluded that programs are effective in reducing admissions in elderly patients [15]
- A DMP program for myocardial infarctions reduced readmissions, emergency room visits and insurance claims [16]
- A study of almost 800 chronically ill Veterans using a web based interactive disease dialogue telemedicine strategy at home was able to show a reduction in emergency room visits (40%), a reduction in hospital admissions (63%), a reduction in hospital bed days (60%), a reduction in nursing home admissions (64%) and a reduction in nursing home bed days (88%). Medication compliance improved as did compliance with national guidelines [17]
- MaineHealth. By using disease registries and focused care, Maine's largest hospital system was able to realize more than $1 million savings annually with reduced emergency room visits and hospitalizations. They focused on asthma, diabetes, depression and heart failure. Physician teams used national asthma guidelines and receptionists used registries to call and remind asthmatics about appointments and flu shots. Visits to emergency rooms dropped from 55% to 16% in certain disease categories [18]
- Grant et al studied the effect of a specific diabetic web portal/personal health record that was integrated with an EHR. Although participants were more likely to have medications changed, their diabetic, blood pressure and cholesterol control was not better than a similar group of patients who had access to a standard web portal. One of the lesions learned was that patient participation in this trial was only 5% of their diabetic population. Also, poorly controlled diabetics were less likely to enroll in such a study [19]
- Peikes et al reviewed 15 disease management programs (Medicare Coordinated Care Demonstration) funded by Medicare. They studies 18,000 patients to determine if care coordination by nurses would improve chronic disease care or decrease costs. Only 2 of the 12 largest programs showed any statistically significant effects on hospital admissions. Expenditures were 8-41% higher in the intervention groups compared to controls. None of the programs generated net savings. They subsequently terminated all but 2 of the programs. They concluded that care coordinators (nurses) must interact with patients in person and not rely on telephones and technology. Also, coordinators must collaborate with the primary care clinicians to be successful [20]
- Kidney specialists working for Kaiser-Permanente in Hawaii wanted to improve the number of referrals from generalists so they could intervene earlier for chronic kidney disease. Because they all used the same electronic health record, they were able to monitor kidney function in the entire population of 214,000 patients. Access to lab results, clinical notes and secure messaging allowed the specialists to contact the generalists with advice and schedule consultations with themselves rather than waiting for the generalists. The end result was the decrease in late referrals from 32% to 12%. This was a good example of using a disease registry to improve population health. Rather than rely on a computerized clinical decisions support, the specialists provided the decision support. They outlined the key features of the EHR-based electronic population management database:
    - Access to comprehensive, current patient information
    - Database permitted risk stratification
    - Ability to annotate records to improve communication
    - Seamless integration of new data into the longitudinal record
    - Electronic messaging between specialists and generalists

- Electronic alerts for deteriorating lab results
- Generation of population level statistics
- Ability to flag patient records by status [21]

In spite of some encouraging reports like those cited above, there are problems with the quality of the studies published thus far, such as lack of randomization or lack of a control group. In addition, many studies do not convincingly prove a reasonable return on investment.

Disease Registries

Definition of an electronic disease registry:

> *"A software application for capturing, managing and providing access to condition specific information for a list of patients to support organized clinical care "*[22]

Registries are tools that disease management programs use to track patients with chronic diseases, such as diabetes. As a result of this data DMPs can remind patients to get lab work done and keep appointments. In addition, they can aggregate data to show, for example, the average hemoglobin A1c levels (blood test to measure blood sugar control) of an entire clinic that could be useful for "pay for performance" (next chapter) programs.

Disease registries are available in several data inputting formats:

- **Manual**: data manually inputted onto paper or a computer database or spreadsheet or into a web based program
- **Automatic**: data automatically inputted into standalone software or web based site using client-server software and integrated with, for example, a laboratory result program using LOINC and HL7 standards
- **Automated and Integrated**: data input, retrieval, tracking and graphing are all automatic and part of an electronic health record. This is the least common scenario currently but is felt to have great potential in DMPs and pay for performance programs

Potential drawbacks of registries include manual data inputting, need for accurate coding, need for frequent updating and need for additional staff to maintain a registry. Disease management team members need to meet on a regular basis to discuss data reports and analysis. With time it is anticipated that more team functions will be automated to streamline workflow. The ultimate solution is to have all clinicians use an electronic health record with an integrated disease management and disease registry application. In this way all fields are automatically populated with patient data, to include lab results, etc. See Figure 12.3.

Approximately 50 disease registries exist that are free or fee based. Cost is usually $500-$600 year per user for commercial registries. In general, free public registries have less functionality than commercial registries. For an excellent in-depth review of 16 registries see Chronic Disease Registries: A Product Review by the California HealthCare Foundation.[23] They also review the IT tools used for chronic disease management. Five California foundations have combined resources to support a $4.5 million project known as "Tools for Quality" to test disease registries for the low income and underserved populations in their state. They have recruited 33 clinics thus far that will be paid on average about $40,000 to acquire and maintain disease registries.[24]

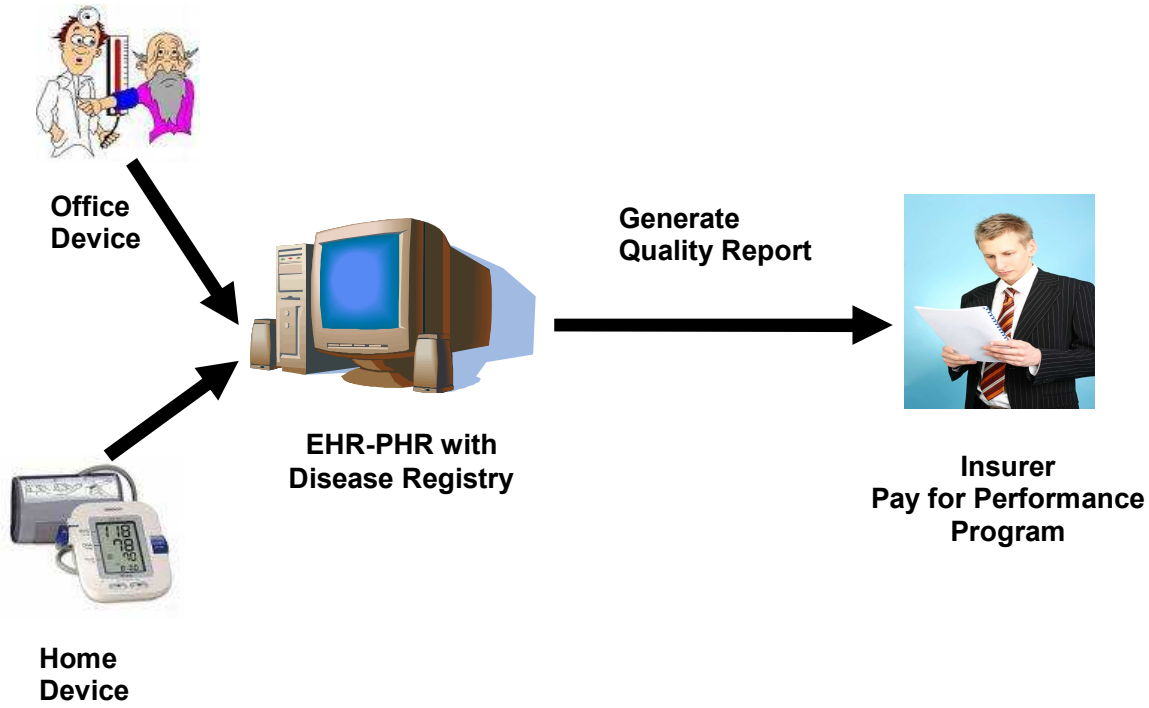

Figure 12.3 Disease registry integrated with EHR to generate reports for pay for performance programs

Disease Registry Examples

Chronic Disease Electronic Management Systems (CDEMS). This popular program is Microsoft Access-based and tracks diabetes and adult preventive health. The program is customizable and includes lab reminders for clinicians. The reports generated are also customizable and users have access to a web forum to discuss issues. A free add-on program inputs data automatically from several laboratory information systems (Quest, Labcorp, Dynacare and PAML). Shortcomings include the need to manually input data and access is limited to ten concurrent users. Support will become fee-based in July 2009.[25]

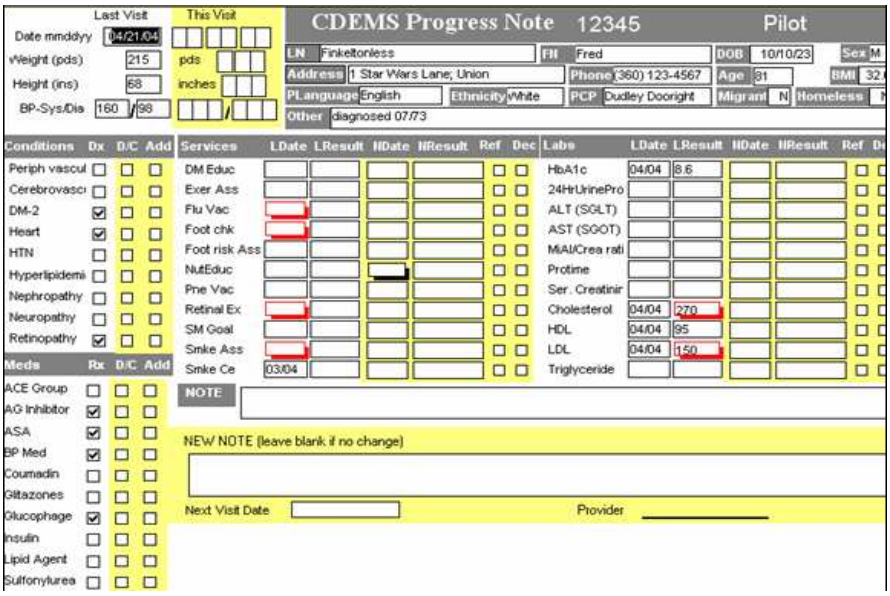

Figure 12.4. CDEMS disease registry (courtesy Washington State Department of Health-Diabetes Prevention & Control Program and Centers for Disease Control - Diabetes Translation Division)

Population Health Navigator (PHN). Population Health Navigator is a program used by the Department of Defense (DOD) to track asthma, beta-blocker use following myocardial infarction, cardiovascular risk factors, breast cancer screening, cervical cancer screening, depression, diabetes, hypertension, COPD, hyperlipidemia, low back pain and high utilizers. Data can be analyzed by physician, clinic or hospital system. Data can be exported to MS Excel for data manipulation. Drawbacks include that it is not integrated into the electronic health record (AHLTA) and data is not available real time (about a 60 day delay). The site is secure and only available to DOD personnel with proper authority.[26]

DocSite Registry. One of the best known web-based commercial registries is Patient Registry by DocSite that will track multiple common diseases. It can be integrated with practice management software, EHRs and e-prescribing systems. Figure 12.5 is a typical clinician report with lab results and due dates. Clinical practice guidelines can be embedded in the registry with the ability to make local modifications. Other features include HL7 links to input lab data, patient education, patient letter generation and the ability to host data locally or on the DocSite server. They integrated the ACP-PIER resource into disease registries in 2008. The charge for this basic registry is $50/clinician/month. They also offer DocSite Enterprise for larger organizations. They continue to evolve and offer integration with pay for performance and medical home models. [27]

DocSite PatientPlanner

Service Activity: Provider Summary

Site: DocSite - Health Care Center

Provider: Dennis Smith

Measure Name	Patient Count	Panel Avg Value	% Met Pt Goal	% Met Pop Goal	% Overdue	Avg Times Checked	Panel Max	Panel Min
HbA1c	68	6.93	56%	56%	0%	5.13	13.00	5.00
HDL	68	45.40	76%	76%	0%	4.49	92.00	24.00
LDL	68	95.49	54%	54%	0%	4.49	251.00	25.00

Provider: Sam Admas

Measure Name	Patient Count	Panel Avg Value	% Met Pt Goal	% Met Pop Goal	% Overdue	Avg Times Checked	Panel Max	Panel Min
HbA1c	83	7.06	49%	49%	0%	5.16	13.00	4.00
HDL	70	41.97	69%	69%	0%	3.80	95.00	16.00
LDL	70	108.63	46%	46%	0%	3.80	207.00	24.00

Provider: Lucy Jones

Measure Name	Patient Count	Panel Avg Value	% Met Pt Goal	% Met Pop Goal	% Overdue	Avg Times Checked	Panel Max	Panel Min
HbA1c	44	7.16	50%	50%	0%	4.57	13.00	4.00
HDL	44	48.84	80%	80%	0%	3.59	104.00	21.00
LDL	44	104.77	45%	45%	0%	3.59	223.00	23.00

Figure 12.5. DocSite PatientPlanner registry (Courtesy DocSite)

EClinicalWorks. This EHR vendor includes disease registries but these are uncommon as part of many electronic health records. This is the ideal format in that patient lists, alerts, reminders, patient education, lab results, CPGs, patient education and reporting could all be part of one information system.[28]

CareManager. CareManager by Kryptiq integrates a disease management program into the GE Centricity EHR. Data therefore approaches real time as opposed to programs based on insurance claims data. Currently, they offer modules for diabetes, stroke prevention, coronary heart disease,

cancer screening, tobacco cessation, asthma, drug safety and osteoporosis. Patient status is color coded (green = good, etc). A pilot project with Providence Medical Group demonstrated a ROI in only 4.5 months as a result of more outpatient visits and a higher level of coding. They also demonstrated improved compliance with multiple diabetic measures such as cholesterol and blood pressure control. Disease dashboards demonstrating their status can be e-mailed to patients. Organizations and physicians can be given performance score cards to mark individual progress. Managers can customize reports for pay for performance programs.[29]

Key Points

- Chronic diseases are on the rise in the USA
- Chronic diseases are costly so disease management programs are commonplace, but benefits are controversial
- Disease management programs benefit from information technology by creating electronic disease registries
- Most current EHRs are in the process of adding electronic disease management programs
- Electronic disease registries will be helpful in managing patients and reporting results to pay-for-performance programs

Conclusion

For Disease Management programs to succeed there needs to be a general mandate to improve the treatment of chronic disease and financial support. Due to the rising costs of chronic diseases, CMS and managed care organizations are interested in new pilot programs. What must be shown is that DM programs improve patient outcomes and save money. It is much easier to show that programs improve processes such as lab tests drawn than improved actual patient outcomes, like fewer heart attacks or strokes. The Congressional Budget Office in Oct 2004 concluded that there was inadequate evidence that DM programs reduced healthcare spending.[30] In some instances they might actually increase costs if more services are recommended.

The new Medical Home Model has recently appeared on the scene and must be evaluated extensively to determine if it will impact the quality of care and significantly decrease healthcare costs for chronic diseases. Proof of long term benefit is evolving at this time. Nevertheless, we believe that information technology can aid the study of diseases and populations greatly.

Ultimately, all electronic health records will have comprehensive disease management features that will be customizable for clinicians and administrators. Data will be easy to retrieve and analyze in a real time mode and will be linked to reimbursement. Until that happens, however, we will rely on a variety of disease registries and disease management systems.

We believe that models that integrate human (nurse, physician, pharmacist, etc) involvement with technology seem to work better than purely technical solutions for disease management at this time.

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13

Pay for Performance (P4P)

ROBERT E HOYT

Learning Objectives

After reading this chapter the reader should be able to:

- State the origins behind pay for performance programs
- Describe the need for automated retrieval of accurate patient data for the success of pay for performance programs
- List governmental pay for performance pilot programs
- List the concerns and limitations of current pay for performance programs for the average clinician

There have been numerous studies since the classic *Crossing the Quality Chasm* that confirm we are not getting our money's worth from American Medicine. As an example, a study by the Commonwealth Fund demonstrated that the quality of care delivered to Medicare recipients was not related to the amount of money spent.[1] The Institute of Medicine (IOM) has been consistently critical of the variance in care and serious patient safety issues. As a result, they have repeatedly called for an increase in payments to clinicians who offer higher quality care. These concerns about "value based care" are further aggravated by the fact that the United States has an annual $2.3 trillion dollar health care price tag that continues to rise each year. The IOM released "Rewarding Provider Performance: Aligning Incentives in Medicare" in September 2006 that had the following key messages:

- *"Fundamental change requires a commitment by all Medicare providers to deliver high quality care efficiently*
- *Pay for performance constitutes one key component needed for the transformation of the healthcare payment system but cannot achieve this transformation alone*
- *Pay for Performance offers significant promise and can begin now by building off other strategies for improvement*
- *In particular, providers should assume accountability for transitions between settings of care and coordinate care in treating patients with chronic diseases*
- *Pay for performance in Medicare should be introduced within a learning system that has the capacity to assess early experiences, adjust for unintended consequences and evaluate impact"*[2]

All of these factors have helped give birth to the notion that we need major changes in the field of medicine, to include how we determine reimbursement for care. No incentives for better quality exist under our current system. The more widgets you make, the more you get paid. The widgets don't have to be made well, just well documented. Using information technology data from electronic claims, electronic health records and disease registries we can measure quality parameters faster and without the need to do paper chart reviews. In fact, some authorities feel that P4P should first pay to create an information technology infrastructure and later reimburse for quality.

P4P (also known as value based purchasing) has gained traction in the United States in a surprisingly short period of time. The momentum may in part be due to the 2004 statement made by Mark McClellan, administrator for the Center for Medicare and Medicaid Services in the Wall Street Journal:

> *"In the next five to ten years, pay for performance based compensation could account for 20-30 percent of what the federal programs pay providers"*[3]

As a further example of the rise of P4P programs, Rosenthal et al in a 2006 article in the New England Journal of Medicine examined the incidence of P4P programs in 252 Health Maintenance Organizations (HMOs). They determined that over half had P4P programs; 90% of programs were for physicians and 38% were for hospitals.[4]

There have been several bills introduced in Congress to address pay for performance but only one has passed thus far. The Tax Relief and Health Care Act of 2006 (HR 6111) implemented a voluntary quality reporting system for Medicare payments tied to claims data. Clinicians who report this information would be eligible for a 1.5% bonus. The new system is called the Physician Quality Reporting Initiative (PQRI) and is discussed later in this chapter.[5]

The concept of P4P is not entirely new as WellPoint (a health plan covering 24 million lives) has had reimbursement based on clinical measurements for about 10 years, but it was not called P4P.[6] Additionally, HealthPartners (Minnesota) has had an Outcomes Recognition Program since 1997.[7]

The principles behind Pay for Performance are aimed at better:

- Quality of patient care
- Patient and clinician satisfaction
- Patient safety
- Reimbursement to clinicians
- Return on investment (ROI)

Table 13.1 shows the type of data that might be used for P4P programs.

Table 13.1. Types and examples of data for P4P programs

Types of data	Examples
Utilization data	Emergency room visits
Clinical quality	Women who have had mammograms
Patient satisfaction	Percent of patients who would recommend their primary care manager
Patient safety	Percent of patients questioned about allergic reactions

Information Technology Issues:

- Most electronic health records (EHRs) are not ready for generating P4P type reports. Ideally, data would be automatically generated from the EHR if the data was inputted into data fields in templates rather than free text. Unfortunately most notes are not written using an electronic template and problem summary lists are not updated often enough to be a data source. Perhaps artificial intelligence will eventually be able to scan a dictated patient encounter and automatically submit a P4P report as well as a coding level. Lab results are easier to report because they are coded by data standards such as LOINC and HL7
- A February 2007 article by Baker on automated review of quality measures for heart failure using an EHR concluded that the current system lacked the ability to tell why a drug was not

started or why it was stopped. Chart reviews were the only way to tell why recommended medications were not used or were discontinued[8]

- There is a need to identify acute versus chronic problems and active versus inactive problems
- Until EHRs are universal, organizations must have a transitional plan like disease registries and disease flow sheets
- Many healthcare systems would benefit from a central data repository (CDR) or data warehouse with a rules engine.[9] Data could be pushed or pulled from the CDR for monthly reports

The Ambulatory Care Quality Alliance (ACQA). In order for P4P to be well received there needed to be a set of outpatient clinical performance measures that would be accepted by clinicians. The Ambulatory Care Quality Alliance, the American Academy of Family Physicians, The American College of Physicians, America's Health Insurance Plans and the Agency for Healthcare Research and Quality met in January 2005 and recommended 26 "starter set" measures.[10] The program looked at *processes* and not actual *patient outcomes*. This is similar to the Health Plan Employer Data and Information Set (HEDIS) measurements that are commonly used today as performance measurements.[11] Process measurements check to see if a test was done and not the actual result. This should allow for easier retrieval of data using administrative or insurance claims data. The goal is to eventually have national ambulatory quality measures in place.

The following are the categories of the proposed starter set measures:

- Preventive measures such as the percent of women who had mammograms or Pap smears
- Coronary heart disease
- Heart failure
- Diabetes
- Asthma
- Depression
- Prenatal care
- Measures to address overuse or misuse of drugs [10]

Pay for Performance Projects

It is estimated that more than 100 organizations have P4P programs in place, in spite of the paucity of studies to prove efficacy or return on investment. Many of the programs are really *pay for reporting* programs, in that, clinicians are being reimbursed for submitting evidence that they checked on an important test, not that the test was optimal or met national recommendations.

Centers for Medicare and Medicaid Services (CMS) Physician Group Practice Demonstration

- First Medicare pay for performance program
- Three year program started in 2005 and involved 10 large physician groups (5,000 physicians and 224,000 patients)
- Used 27 quality measures
- Most purchased EHRs and disease registries to aid reporting
- Practices would keep up to 80% of savings from program
- Overall, most practices improved the quality of care[11-12]

Physician Quality Reporting Initiative (PQRI)

- Medicare program that began in 2007 to reimburse for reporting quality measures
- It is a pay-for-reporting initiative
- You can report individual quality measures, disease/condition-specific measures or reports through disease registries (that could be part of an EHR)
- In 2009 the bonus is 2% (1.5% prior years) of the total Medicare allowable charges during the reporting period. This would amount to about $4,000 per primary care physician
- Data on 30 consecutive patients must be submitted[13]
- Information about how to submit patient data with a disease registry or EHR are available at www.QualityNet.org
- Clinicians are paid the following year and this delay has not been well received according to a physician survey. In addition, clinicians have been slow to receive feedback on their progress from CMS[14]
- A commercial disease registry DocSite is ready to submit reports to Medicare for a flat fee of $350[15]
- The PQRI experience of one medical group was reported in 2008. In spite of this group having an EHR, they had to create a new software program in order to create a PQRI report[16]

Centers for Medicare and Medicaid Services (CMS) Premier Hospital Quality Incentive Demonstration Project

- 270 hospitals began participating in October 2003
- Hospitals are paid based on compliance with 34 quality indicators in 5 common areas (heart attack, heart failure, pneumonia, bypass surgery and hip/knee disease)
- $7 million given out yearly for 3 years as bonuses
- Three year demonstration project
- Program uses the Premier Perspective database, the largest in the nation, currently with 3 billion patient records
- After review of first year data, hospitals scoring in the top 10% received a 2% bonus in Medicare payments. Hospitals scoring in the second 10% received 1% and those below got nothing
- It is possible for hospitals to have a 1-2% decrease in Medicare payments if at year three they have not improved beyond the baseline
- $8.85 million awarded to top 123 performers
- Demonstration project for nursing homes is likely in the future
- Actual improvements in quality measures documented in the first year of the project:
    - Increase from 90 percent to 93 percent for patients with acute myocardial infarction (heart attack)
    - Increase from 86 percent to 90 percent for patients with coronary artery bypass graft

  - Increase from 64 percent to 76 percent for patients with heart failure
  - Increase from 85 percent to 91 percent for patients with hip and knee replacement
  - Increase from 70 percent to 80 percent for patients with pneumonia
- A two year report was published in February 2007 in the New England Journal of Medicine and showed:
  - After adjusting for baseline performance, P4P programs were associated with improvements in the 2.6 - 4.1% range, compared to hospitals that reported but were not part of the program
  - It is unknown what the actual return on investment was for the average participating hospital
  - Patient outcome information is unknown. In other words, did better compliance to guidelines result in fewer deaths and complications?
  - Would the results have been better with a higher incentive?
- A three year report was available on the Premier web site in June 2008 and showed a 15.8% improvement over the previous 3 years. As a result the project will be extended till 2009[17-18]

Centers for Medicare and Medicaid Services (CMS) Medicare Care Management Performance Demonstration

- Passed in late 2006 as part of section 649 of the 2003 MMA
- Three year demonstration project for small to medium sized practices in the states of Arkansas, California, Massachusetts and Utah
- In the first year practices will only report baseline quality data and will be paid for reporting
- Reimbursement could be up to $10,000 per physician and $50,000 per practice
- Implies they need information technology for data retrieval and reporting
- Reimbursement levels may be too low[19]

Surgical Care Improvement Project (SCIP)

- Similar Medicare P4P project for surgical care
- Project will look at post-surgery: site infections, adverse cardiac events, deep vein thromboses (blood clots in the legs) and pneumonia
- Program began in July 2005[20]
- Many hospitals will rely on labor-intensive retrospective chart reviews, but at least one facility will use a new software application to record live data (concurrent documentation)[21]

Bridges to Excellence

- Is a consortium of employers (General Electric, Procter and Gamble, Verizon Communications, Raytheon Company, UPS, Humana, Ford Motor Company and Cincinnati Children's Hospital Medical Center), health plans (Aetna, Anthem Blue Cross/ Blue Shield of Ohio and Kentucky, Blue Cross /Blue Shield of Illinois, Alabama and Massachusetts, Tufts Health Plan, United Healthcare, Harvard Pilgrim Healthcare and Humana) and physician groups in 10 states
- Their goal is to raise quality and drive down costs

- They target office systems (IT), diabetes, depression, spine care, cardiac care and the medical home model
- Program paid out about $2 million in 2005 to clinician groups who adopted P4P [22]
- A 2009 review article showed a strong correlation between reimbursement and physician participation [23]

Providence Health Systems

- PHS has 17 hospitals in California, Oregon, Washington and Alaska
- Since 2003, PHS has collaborated with Kryptiq (data integrating company) to develop a tool that uses EHR data for disease management
- Program plans to have about 15 disease modules
- Improvement in compliance to national guidelines already seen [24]

CareFirst Blue Cross/Blue Shield

- Will pay up to $20 thousand for installing EHRs
- Part of Bridges to Excellence program
- Plans to spend about $3.6 million over 3 years for P4P [25]

Blue Cross Blue/Shield of Michigan

- Paid $1 million in bonuses in April 2005 to physicians who encouraged patients to use less expensive drugs and follow clinical practice guidelines (CPGs)
- Approximately 2,400 physicians enrolled
- On a trial basis physicians were given 0.5% less in 2006 to create a pool of money [26]

California Pay for Performance Collaboration

- Seven major insurance companies (HMOs) and 225 medical groups have organized towards P4P since 2000
- Serves 6.2 million patients
- P4P bonuses totaled $203 million between 2004 to 2007
- Program uses aggregate insurance claims data that is publicly reported and managed by an independent source
- Funded through multiple sources
- Second year data showed gains in all areas of clinical quality
- Groups with more IT did better
- The 2005 measures for P4P were divided into the following categories:
    - Prevention and Disease Management 50%
    - Patient Satisfaction 30%
    - Information Technology 20% [27]

- A follow-on survey reported in 2009
    - Only a handful could provide reports that would drill down to the physician level
    - Reimbursement was 1-5% of salary which was perhaps too low
    - Overall, progress was felt to be modest [28]

HealthPartners Outcomes Recognition Program

- Began in 1997 and later called P4P in 2001
- In 2004 it paid $5.6 million to primary care groups, $1 million to specialty groups and $4 million to hospitals
- Payouts: 25% for patient satisfaction, 75% for measures of diabetes, coronary disease, preventive services, tobacco cessation and use of generic drugs
- Pays for outcome measures and not just process improvement [29]

The British Experience

- Although some P4P programs began in 1990, the current extensive program has existed only since April 2005
- Program involves 10 chronic conditions
- Most data will come from practitioner's computers and the PRIMIS (primary care information services) that provides free of charge:
    - **Training** in information management skills and recording for data quality
    - **Analysis** of data quality, plus a comparative analysis service focused on key clinical topics
    - **Feedback** and interpretation of the results of data quality and comparative analyses
    - **Support** in developing action plans [30]
- Practitioners operate on a points system with a possible total of 1050 points gained
- Program could result in potentially as much as $77,000 per physician [31]

Clear Choice Health Plans

- Opted to use three measures of quality for P4P awards program:
    - Use of evidence based medicine by accessing the medical resource UpToDate
    - Appropriate ordering of images by accessing the American College of Radiology web site that lists appropriateness criteria
    - Self improvement by accessing a reporting web site www.managedcare.com [32]

State Medicaid Programs

- A majority of states plan for P4P programs in the next 5 years, according to a survey by the Commonwealth Fund
- Alabama, Alaska, Arizona, Massachusetts, Minnesota, New York, Pennsylvania and Utah will offer incentives to clinicians who adopt EHRs and/or e-prescribing
- Most Medicaid directors stated that their emphasis was on quality and not on saving costs [33]

P4P Concerns and Limitations

The following are some of the concerns about P4P programs expressed primarily by physicians and their organizations:

- Does it discriminate against practices without EHRs?
- Are EHRs sophisticated enough to provide accurate measures of quality?
- Should data be public?
- Should reporting be voluntary?
- Will it cause clinicians to "dump" non-compliant patients?
- Will it result in higher quality care or long term return on investment?
- Will it adjust for sicker, poorer and more elderly patients?
- Much of the practice of medicine does not have identified quality measures, so P4P will not apply
- Will the motive be money and not quality?
- Is a bonus of 5-10% of yearly compensation adequate for P4P programs?
- Is the extra work to report actually worth the small payment?
- Do P4P programs favor large medical groups?
- Should data come from a centralized data repository?
- Will P4P work outside health maintenance organizations (HMOs)?
- Should bonuses be paid for improvement even if results do not meet national goals?
- At this time, the majority of P4P reimbursements go to primary care physicians and not specialists or hospitals
- Waiting on "report cards" occasionally takes a long time and impedes next year's improvement [34-40]
- Physicians are still skeptical

Current status of pay for performance programs

On a positive note, P4P has the potential to blend evidence based medicine, disease management, clinical practice guidelines, electronic health records and information technology. Nevertheless, P4P programs have their share of obstacles. There have been multiple P4P articles written that are both pro and con in the lay press, but little written in the medical literature. In a 2005 article by Rosenthal et al in the Journal of The American Medical Association, they reported a study comparing P4P in a large California physician group compared to a control group. The measurements studied were Pap smears, mammograms and Hgb A1C (diabetic) testing. There was very little improvement noted except for modest improvement in Pap smear testing. In spite of the $3.4 million payout by the health plan, the conclusion of the study was

> *"Paying clinicians to reach a common, fixed performance target may produce little gain in quality for the money spent and will largely reward those with higher performance at baseline".*[41]

A 2006 systematic review by Petersen et al was unable to prove that P4P incentives have been shown to improve the quality of care.[42]

Until better evidence is available we should proceed cautiously and be sure performance measures are fair and equitable as outlined by the Medical Group Management Association (MGMA) 2005 principles:

- The primary goal must be improving health quality and safety
- Participation by practices should be voluntary
- Physicians and professional organizations should be involved in P4P design
- P4P measures must be evidence based, broadly accepted, clinically relevant and continually updated
- Physicians should have the ability to review and correct performance data
- P4P must reimburse physicians for any administrative burden
- P4P must reward physicians' use of electronic health records and decision support tools [43]

Key Points

- US Medicine is the most expensive in the world, yet many important outcomes such as infant mortality demonstrate worse results than other countries who spend less money
- Civilian and federal insurers are beginning to look at reimbursing for quality, instead of quantity
- Measuring quality will be difficult and controversial but will likely benefit from information technology, particularly the electronic health record
- Multiple pay for performance projects are underway
- It is unknown whether current pay for performance programs will have any significant impact on improving the quality of medical care

Conclusion

The jury is out regarding pay for performance programs. No one disputes the need to change reimbursement to better reflect performance and not just volume. Current fledgling P4P programs measure process and not actual patient outcomes which dilutes the significance of any results. Information technology is mandatory in order to make reporting rapid, accurate and paperless. Electronic health records with disease registries and pre-formatted pay for performance reports seem to have the most potential. Importantly, further research will need to determine how much pay will be required for how much performance.

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14

Patient Safety and Technology

ROBERT E HOYT

Learning Objectives

After reading this chapter the reader should be able to:

- Identify why patient safety is a national concern
- List the perceived causes of patient safety concerns
- Describe the role of information technology in improving patient safety
- Compare and contrast the private and governmental patient safety programs
- List the various technologies that are likely to improve medication error rates such as computerized physician order entry
- Identify the obstacles to widespread implementation of patient safety initiatives

The following statement was posted by a bioengineer after the tragic death of Betsy Lehman, a well known Boston columnist who died from an excessive dose of chemotherapy in 1995:

> *"How long, Oh Lord, must this continue? In 1974 we had an on-line patient record system that flagged unusual lab results or unusual prescriptions, and that was at a veteran's hospital. That's 21 years ago. Isn't it time that basic computerization be part of the expected and required care at medical facilities? That humans make 0.1 percent errors on prescriptions may be forgivable; that hospitals don't take obvious actions to protect themselves and patients, well within state-of-the-art, is not"*[1]

Another sobering statistic about United States healthcare is that those activities that result in more than one death per 1000 encounters include bungee jumping, mountain climbing and healthcare. Dr Lucian Leape from the Harvard School of Public Health in 1994 estimated that 180,000 patients die each year as a result of medical errors which is the equivalent of three jumbo jets crashing every two days. Surprisingly, he also pointed out that a literature search in 1992 resulted in no articles on preventing medical errors. According to Dr. Leape, the only specialty in Medicine that has experienced dramatic advances in patient safety is Anesthesiology, with less than one death in 200,000 patients undergoing anesthesia.[2] Other industries such as the airlines have dramatically reduced mishaps thru initiatives such as "crew resource management" (CRM).[3] This technique has been so successful hospitals often incorporate CRM as part of training. Besides the obvious increased mortality and morbidity that results from medical errors there is a resulting increase in litigation. It was estimated in 2003 that US malpractice costs totaled $27 billion.[4]

One of the basic premises of this chapter is:

- Technology can improve the quality of medical care
- Improved quality of care means improved patient safety
- Technology can therefore improve patient safety

What is missing, unfortunately, are high quality research articles that prove this premise. Let us start to look at patient safety further by highlighting some of the current shortcomings of US medicine.

The United States Medical Report Card

World Health Organization (WHO). Table 14.1 shows that the US spends a greater percent of their gross national product (GNP) on healthcare compared to other countries, but life expectancy is not substantially better. Based on available outcome measures, the United States is generally in the bottom half and its relative ranking has been declining since 1960.[5]

Table 14.1 Percent of Gross National Product (GNP) spent on healthcare and life expectancy in years

Country	GNP % Spent on Healthcare						Life expectancy 2007 (years)
	1997	1998	1999	2000	2001	2006	
Australia	8.5	8.6	8.7	8.9	9.2	8.7	82
France	9.4	9.3	9.3	9.4	9.6	11	81
Japan	6.8	7.1	7.5	7.7	8	8.1	83
United Arab Emirates	3.6	4	3.7	3.5	3.5	2.5	78
United Kingdom	6.8	6.9	7.2	7.3	7.6	8.2	80
Tanzania	4.1	4.4	4.3	4.4	4.4	6.4	52
USA	13	13	13	13.1	13.9	15.3	78
Uruguay	10	10.2	10.7	10.9	10.9	8.2	75

Rand Study 2003

Some have argued that one of the causes of decreased patient safety is the failure of US physicians to follow national clinical practice guidelines. A telephone survey of 13,275 adults living in 12 urban areas in the US was conducted that looked at quality indicators for 30 acute and chronic conditions including preventive care. The conclusion was that participants received only 55% of recommended care. It is unknown, however, how often patient non-compliance or lack of finances played a role in patients not receiving the recommended care. It cannot be assumed that the primary reason for low compliance to guidelines was an insufficient effort on the part of clinicians.[6]

Institute of Medicine (IOM) Reports

The 1999 Institute of Medicine report *To Error is Human* estimated that at least 98,000 inpatients die every year and 1,000,000 are injured due to preventable errors.[7] The mortality and morbidity rate may have been actually higher as outpatient adverse events were not reported.[8] However, McDonald and others argue that the methodology used to report these statistics was flawed due to a lack of a control group.[9] The 2001 Institute of Medicine report *Crossing the Quality Chasm* stated that there has been little progress since the first report. No congressional action has taken place since the first IOM report. The current medical system was described as an "*era of Brownian motion in health care*". Furthermore, the IOM commented on three categories of medical errors:

- ***Overuse:*** widespread use of antibiotics for viral infections; 32% of carotid artery surgeries were clearly inappropriate and 32% were equivocal
- ***Underuse:*** vaccines, cancer screening, beta blockers post heart attack, etc
- ***Misuse:*** 36% of patients with active tuberculosis were not treated with four drugs initially, as recommended

The IOM has long been an advocate of using information technology to improve healthcare, particularly patient safety. The 2001 IOM Executive Summary recommended that we "improve access to clinical information and support clinical decision making" and "create a national information infrastructure to improve health care delivery and research". Also, their goal is to eliminate handwritten notes in the next decade.[10] The IOM's 2004 *Patient Safety: Achieving a New Standard for Care* repeated the same recommendations.[11]

HealthGrades 2008 Hospital Quality in America Study

This organization reviewed 41 million Medicare patient records from 5,000 hospitals from 2004-2006. They concluded that although mortality continues to improve there were wide gaps between the best and the worst hospitals. They report that medical errors cost Medicare $8.8 billion and resulted in more than 230,000 potentially preventable deaths. There was a 43% lower chance of experiencing one or more medical errors in the best compared to the worse hospitals studied. The rate of hospital acquired infections correlated best with overall performance. The leading 6 safety and quality issues measured were:

- Post operative sepsis (severe infection)
- Post-operative respiratory failure
- Decubitus ulcers (bed sores)
- Post-operative pulmonary emboli or DVTs (blood clots)
- Hospital acquired infections
- Failure to rescue (not recognizing and treating a deteriorating patient)

Samantha Collier MD of HealthGrades believes that the hospitals that traditionally have excellent safety scores have a "culture of safety" and they are the ones that have all of the mechanisms including technology in place to prevent and track patient safety issues.[12]

Commonwealth Fund Study 2007

This was a Survey of more than 700 adults and primary care physicians from the United States, Australia, Canada, Germany, New Zealand and the United Kingdom. The results from 2004, 2006 and 2007 send the same message regarding problems with the US system. In spite of spending the most money, the United States was rated last in several areas, to include safe care. The US differed from the other countries studied in that it did not offer universal health insurance. The US reported the highest number of medical errors and 50% of US adults stated they went without medical care in the past year due to high cost; as compared to 13% for the United Kingdom.[13]

Why is the USA Healthcare report card unfavorable?

In *Crossing the Quality Chasm* the IOM states the problem of poor medical care is based on the:

- The growing complexity of science and technology
- The increase in chronic conditions, e.g. obesity, diabetes and heart failure
- Poorly organized delivery systems that are not organized around patient safety
- The constraints on exploiting the revolution in information technology [10]

A well known healthcare consultant, Dr William Yasnoff, states that medical care in the United States is sub-standard because:

- Medical error rates are too high
- Healthcare quality is inconsistent

- Medical research results are not rapidly used
- Healthcare costs are escalating
- New technologies continue to drive up costs
- Baby boomers will greatly increase demand
- The capacity for early detection of bioterrorism is minimal[14]

According to the Agency for Healthcare Research and Quality, there is too much variation in medical care within the United States as demonstrated by variation in coronary angiography rates between states (Fig. 14.1).[15] The implication is that some areas may perform too many surgeries or procedures compared to other areas that may perform far fewer. As a rule, urban and affluent areas have more specialists and better insurance coverage influencing this disparity.

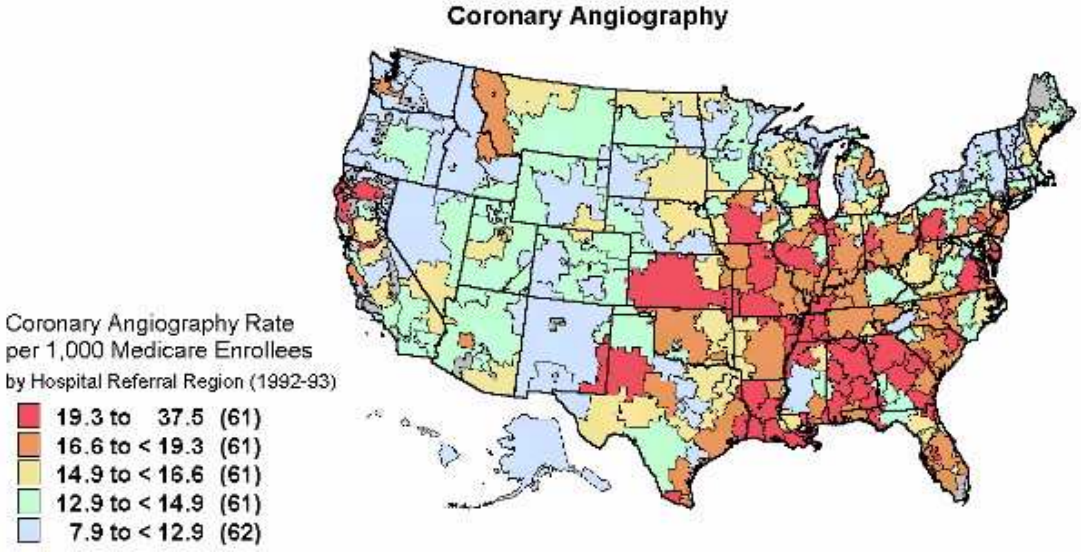
Coronary Angiography
Coronary Angiography Rate
per 1,000 Medicare Enrollees
by Hospital Referral Region (1992-93)
19.3 to 37.5 (61)
16.6 to < 19.3 (61)
14.9 to < 16.6 (61)
12.9 to < 14.9 (61)
7.9 to < 12.9 (62)

Figure 14.1 US Coronary Angiography Rate (adapted from AHRQ web site)

In addition, there are significant differences between early landmark trials resulting in national recommendations and widespread implementation, as shown in table 14.2.[16]

Table 14.2 Current Rate of Use of Landmark Trial Results

Clinical Procedure	Landmark Trial	Current rate of use
Flu vaccine	1968	64% (2000)
Pneumococcal Vaccine	1977	53% (2000)
Diabetic eye exam	1981	48.1% (2000)
Mammography	1982	75.5% (2001)
Cholesterol Screening	1984	69.1% (1999)

Barriers to Improving Patient Safety through Technology

- **Organizational.** US Medicine is primarily a decentralized system with no unifying philosophy. Many small physician groups have no loyalty to hospitals or other healthcare organizations. They do not interact with other physician offices or healthcare organizations and do not share data.

- **Financial.** Who will pay for what? It is estimated that it will cost $500-700 billion dollars over the next 10 years to have a full fledged interoperable electronic health record nationwide. This is 3-4% of the total health care budget which is a lower percentage than what other industries spend on technology. In 1996 the healthcare industry spent about $543 per worker as compared to $12,666 per worker spent by security brokers and other industries for information technology.[17]
- **Trained HIT Workforce.** How can we train and implement technologies such as electronic health records for everyone without expanding the number of health IT workers? It has been estimated that we need between 50-75,000 trained HIT workers. The lack of trained clinical informaticians is also covered in the first chapter.
- **Privacy.** HIPAA concerns continue to be an obstacle to many developments in technology.
- **Security.** Several major episodes of identity theft have alarmed patients and staff and have contributed to the slow adoption of electronic health records and other technologies.
- **Behavioral.** Some would argue that the medical profession has "*mural dyslexia"* or the failure to see the handwriting on the wall. This is due to a fear of change and an underlying skepticism by the medical profession. It is also unclear if physicians and the public view patient safety as a major issue. An article published in 2002 showed that neither group ranked medical errors at the top of problems facing medicine. Furthermore, 70% of the public and 25% of physicians thought errors should be reported to a state agency and only 19% of physicians and 46% of the public thought that computerized physician order entry (CPOE) was an effective way to reduce errors.[18]
- **Error reporting.** Reporting continues to be voluntary and inadequate at best. In a recent study of over 90,000 voluntary electronic error reports from 26 hospitals, only 2% were reported by physicians, most were from nurses.[19] A survey of over 1000 physicians revealed that 45% did not know if their institution had an error reporting system. Seventy percent thought the current reporting systems were inadequate. Physicians believed reporting would improve if information was kept confidential, nondiscoverable, it was quick to input and it was nonpunitive.[20]

Currently, there is no universal method to standardize error reporting in the US. The FDA and NIH plans to make a new adverse reporting portal available in late 2009. The portal is known as MedWatch Plus Portal that allows consumers, clinicians, researchers and device makers to report adverse events, medical errors, product and device complaints. This will include problems with human and animal food.[21-22]

Previously, alerts to physicians about defective devices and drug alerts were mailed. To improve the situation the Health Care Notification Network was created that will e-mail alerts as well as public health emergencies and bioterrorism events.[23-24]

What is the Federal Government doing about patient safety?

Agency for Healthcare Research and Quality (AHRQ)

The AHRQ is an agency under the Department of Health and Human Services. One of its goals is to provide grant money for research to reduce medical errors. This includes research using information technology. Importantly, the agency developed the AHRQ Patient Safety Network that includes an e-mail newsletter with medical literature reviews of patient safety articles.[25]

Patient Safety and Quality Improvement Act S.544

This patient safety initiative became law in 2005 and called for voluntary reporting of medical errors without recrimination. The Department of Health and Human Services maintains databases to collect data. This act is limited by the fact that there is no definition of "error" and data can only be used in a criminal case and with the physician's permission. Also, it is unclear what the incentive is for the average physician or hospital to report errors.[26]

Centers for Medicare and Medicaid Services

Effective October 1, 2008 Medicare stopped reimbursing hospitals for complications they deemed preventable. At this time, this new policy does not affect physicians. The list of non-reimbursable complications included:

- Objects left in a patient during surgery and blood incompatibility
- Catheter-associated urinary tract infections
- Pressure ulcers (bed sores)
- Vascular catheter-associated infections
- Surgical site infections
- Serious trauma while hospitalized
- Extreme blood sugar derangement
- Blood clots in legs or lungs[27]

What are the States doing about patient safety?

Florida became the first state to openly report a range of cost and quality measures for both hospitals and outpatient facilities. Two web sites were created. The first was www.FloridaCompareCare.gov that provides broad coverage of data such as infection and mortality rates, in addition to costs for common operations. The second site www.MyFloridaRx.com lists pricing information for the 50 most common drugs prescribed in Florida.[28] At this point there is inadequate evidence that simply reporting quality and cost to patients affects their choices or outcomes.

What are private agencies doing about patient safety?

The Joint Commission

Four of the twelve applicable ambulatory 2009 National Patient Safety Goals have health IT implications:

- Improve the accuracy of patient identification: potential for bar coding or RFID
- Improve the effectiveness of communication among caregivers: expedite critical test results to clinicians by using cell phones or voice over Internet protocol (VoiP). Other examples are patient portals, telemedicine and health information organizations
- Improve the safety of using medications: examples could be the use of online or PDA/smartphone drug programs as well as clinical calculators
- Accurately and completely reconcile medications across the continuum of care: if all pharmacy records were online and linked by a health information organization it would be easy to reconcile all medications

In 2008 the Joint Commission recommended that there be one national infrastructure to measure and track quality improvement data.[29] In addition they warned healthcare organizations about new

technologies that potentially cause new patient safety concerns if there is inadequate training and testing.[30]

Institute for Healthcare Improvement (IHI)

The IHI instituted a plan in December 2004 to save 100,000 lives from medical errors by getting hospitals to incorporate at least one of six safety measures. A report on June 14th 2006 estimated that 122,300 deaths have been prevented through the adoption of new safety measures by more than 3,000 participating hospitals over an 18th month period.[31] It should be noted that none of these methods directly involved information technology.

LeapFrog Group

LeapFrog is a consortium of healthcare purchasers that demand better quality. One of the four areas they promote is the adoption of inpatient computerized physician order entry (CPOE). They maintain survey safety data from over 1,000 hospitals as well as a calculator to determine return on investment (ROI) for hospital pay for performance programs. Unfortunately, in 2004 only four percent of hospitals surveyed had fully implemented inpatient CPOE! [32]

HealthGrades

HealthGrades is an organization that rates different aspects of medical care. Some of the reports are associated with charges ($7.95). Hospital reports compare 28 surgical procedures or diagnoses by state. Physician reports compare disciplinary action, board certification and patient opinions. Medical cost reports compare cost information for 56 common procedures to include doctor, hospital, lab and drug costs and include out of pocket costs and average health plan payments.[33]

Information Technology and Patient Safety

Medication error reduction remains the most important patient safety area impacted by healthcare IT. Safety organizations mandate that patients receive the "five rights" before medication administration: right drug, right patient, right dosage, right route and right time. A *medication error* is defined as a failure of a planned action to be completed as intended; that includes errors of omission and commission. It does not imply any damage to the patient. *Adverse drug events*, on the other hand, are defined as any injury due to medication such as a rash, confusion, etc. It has been shown that injury from medications or adverse drug events (ADEs) accounts for up to 3.3 % of hospital admissions.[34] To compound the issue, serious ADEs reported to the FDA increased about 2.6 fold from 1998 to 2005, as did fatalities due to medications.[35] While the IOM cites a study that 7,000 deaths occurred in 1993 due to medication errors, Rooney maintains that 31% of deaths cited were actually due to drug overdoses.[36] Fortunately, 99% of medication errors do not result in injury. About 30% of ADEs are preventable and of those about 50% are preventable at the ordering stage.[37] It is worth noting that CPOE does not prevent errors of administration or timing.[38]

In spite of the fact that more drugs are prescribed for outpatients, inpatient drug use is more dangerous. Intravenous (IV) medications are associated with 54% of ADEs and 61% of serious or life threatening errors.[39] The 2007 monograph by the Institute of Medicine entitled Preventing Medication Errors made several salient points:

- On average, a hospital patient is subject to one medication error per day
- The IOM estimates that about 1.5 million preventable ADEs occur yearly with about 400,000 preventable ADEs occurring in inpatients

- Estimated cost of $5,857 per inpatient error resulting in about $3.5 billion in 2006 dollars due to longer length of stay and additional services, but excluding litigation
- The IOM maintains that estimates are probably low, based on how statistics were collected[40]

Technology has great potential in reducing medication errors, but it is not a panacea. As an example, an article by Oren on technology and medication errors concluded that well controlled studies are lacking, tend to be reported only at a select number of universities and patient outcomes are lacking.[41] Moreover, in a systematic review on the impact of HIT on quality, efficiency and cost reduction the point is made that four institutions are responsible for the majority of what is written on the subject; Brigham and Women's Hospital, Regenstrief Institute, Veterans Administration Hospital system and LDS Hospital/Intermountain Healthcare.[42] In spite of that fact, there is evidence of IT innovations impacting patient safety elsewhere. The Naval Hospital Portsmouth created a Patient Management Page for its housestaff. Selecting a button for the correct ward team brings up a window "pending results for patients discharged from ward" (personal communication July 1 2008). In this way clinicians can be sure lab results, not available prior to discharge, are checked and the results forwarded to the next clinician.

An article in Health Affairs in mid-2008 reported on adoption of medication safety related HIT by 4,561 non-federal hospitals in 2006. The IT applications studied were: electronic medical records, clinical decision support, CPOE, bar coding medication dispensing (BarD), medication dispensing robot, automated dispensing machine, electronic medication administration records (eMAR) and bar coding at medication administration (BarA). They concluded the following:

- Larger and urban hospitals had much higher adoption rates
- On average, only 2.24 of eight applications were adopted per hospital
- One forth of hospitals had not adopted any of the eight technologies
- Teaching hospitals had higher rates of adoption
- The most widely adopted application was the automated dispensing machine and least adopted was bar coding for medication administration (BarA)[43]

A 2007 survey by the American Society of Health-System Pharmacists evaluated the adoption of pharmacy IT in the United States. They surveyed 4112 pharmacy directors (1066 surveys returned (26%) at small, medium and large civilian government and VA hospitals. They published the following conclusions:

- 50% of respondents had at least one component of an EHR; 6% were paperless; 12% had CPOE with clinical decision support; 40% had digital documentation; it was a challenge for EHRs to connect to pharmacy IT systems and be available on all hospital units
- 24% reported having barcode medication administration systems
- 44% reported the use of smart pumps
- 83% reported use of automated dispensing cabinets for drugs
- 10% reported use of pharmacy robots
- 21% reported using e-prescribing
- 10% reported a completely electronic medication reconciliation application
- 8.5% have electronic medication administration records (eMar); 54% use a paper-based system; 20% had an eMar bundled with barcoding and electronic nursing documentation
- 36% of respondents has pharmacy IT personnel[44]

For the sake of completeness we will mention that diagnostic errors are also a concern in regards to patient safety. A Harvard Medical Practice Study suggested that 17% of preventable errors were due to a misdiagnosis.[45] Older studies utilizing autopsies for inpatients that died

revealed about 35-40% of patients died due to the wrong diagnosis.[46] Unfortunately, we currently request autopsies infrequently so we can no longer correlate pre and post-mortem diagnoses. Although we don't have any evidence at this point that technology improves diagnostic accuracy, it seems likely that better imaging and better and faster online resources result in improved diagnostic accuracy.

Technologies That Have the Potential to Decrease Medication Errors:

1. **Computerized Physician Order Entry**
    a) **Inpatient CPOE**. This functionality was recommended by the IOM in 1991. Most studies so far have looked primarily at inpatient CPOE and not ambulatory CPOE. A 1998 study by David Bates in JAMA showed that CPOE can decrease serious inpatient medication errors by 55% (relative risk reduction).[47] Many of the studies showing reductions in medication errors by the use of technology were reported out of the same institution. Other hospital systems are unlikely to enjoy the same optimistic results. A 2008 systematic review of CPOE with CDS by Wolfstadt et al only found 10 studies of high quality, and those dealt primarily with inpatients. Only half of the studies were able to show a statistically significant decrease in medication errors and none of the studies were randomized. Of the ten studies, seven evaluated homegrown (not commercial) CPOE/CDS systems so results are difficult to generalize.[48]

    With the inception of CPOE we are, in fact, seeing evidence of new errors that result from technology. A December 2005 article in *Pediatrics* suggested that the mortality rate increased from 2.8% to 6.5% after implementing Cerner's EHR at Children's Hospital of Pittsburgh. They point out however, with the new system they could not use it "*until after the patient had physically arrived*" and registered in the system. This may have led to delays in diagnosis and treatment. The situation was corrected and we will have to see if mortality rates drop back down to baseline.[49] In another article in the July 2006 journal *Pediatrics* from Children's Hospital and Regional Medical Center in Seattle, they implemented the same EHR and found no increase in mortality. It appears that this was due to better planning and implementation. In this same article Dr Del Beccaro stated that the CPOE system: eliminated handwriting errors, improved medication turnaround time and helped standardize care.[50] An article by Nebeker demonstrated that substantial ADEs continued at a VA hospital following the adoption of CPOE that lacked full decision support, such as medication alerts.[51] A study of pediatric inpatients admitted to hospitals with the Eclipsys EHR showed a reduction in preventable adverse drug events (46 vs. 26) and potential adverse drug events (94 vs. 35) compared to pre-EHR statistics.[52] Suffice it to say that clinicians and staff must be properly trained in CPOE; otherwise errors will likely increase, at least in the short term.

    b) **Outpatient CPOE**. Americans made 906.5 million outpatient visits in the year 2000. Although the initial attention was on inpatient CPOE, by sheer numbers there is more of a chance for a medication error written for outpatients. According to an optimistic report by the Center for Information Technology Leadership, adoption of an ambulatory CPOE system (ACPOE) will likely eliminate about 2.1 million ADEs per year in the USA. This would prevent 1.3 million ADE-related visits, 190,000 hospitalizations and more than 136,000 life threatening ADEs. It is estimated that ambulatory CPOE could save as much as $44 billion/year.[53] A 2007 systematic

review of outpatient CPOE by Eslami was not as optimistic. They concluded that only 1 of 4 studies demonstrated reduced ADEs; 3 of 5 studies showed decreased medical costs; most showed improved guideline compliance; it took longer to electronically prescribe and there was a high frequency of ignored alerts.[54] Kuo, et al reported medication errors from primary care settings. 70% of medication errors were related to prescribing, 10% were administration errors, 10% were documentation errors, 7% dispensing errors and 3% were monitoring errors. ADEs resulted from 16% of medication errors with 3% hospitalizations and no deaths. In their judgment, 57% of errors might have been prevented by electronic prescribing.[55]

CPOE may have other safety implications, besides medication safety. Casolino et al reported on how often patients fail to hear about lab results such as mammograms, Pap smears and stool specimens for blood. They concluded that about 1 in 14 abnormal tests are not adequately reported to patients and/or not documented in the chart. Of the 23 practices studied this failure rate varied from 0%-25% and the most significant problem was that some practices failed to have an "iron clad" plan to notify patients. The worst case scenario was when a practice had a mixed system of either a paper record and electronic lab results or vice versa. This study reinforces the concept that safety processes and work flow must be worked out ahead of time and apparent to all clinicians or problems will occur, regardless as to whether you use a paper-based system or an EHR.[56]

c) **Clinical Decision Support**. Computerized drug alerts have obvious potential in decreasing medication errors but have not been very successful to date. According to a systematic review by Kawamoto et al, successful alerts need to be automatic, integrated with CPOE, require a physician response and make a recommendation.[57] In an interesting study of all alert overrides for 3 months at Brigham and Women's Hospital in Boston they noted that 80% of alerts were over-ridden because: 55% of respondents stated they were "*aware of the issue*"; 33% stated "*patient doesn't have this allergy*" and 10% stated "*patient already taking the medicine"*. Only six percent of patients experienced ADEs from alert overrides but half were serious. Their conclusion was that alert overrides are common but don't usually result in serious errors.[58] In a newer study at the same institution of outpatient alerts, they found better acceptance when alerts were interruptive only for critical situations. Sixty seven percent of interruptive alerts were accepted which represents an improvement. Many alerts were still incorrect so further improvements are needed.[59] In a third study from Brigham and Women's Hospital, critical lab alerts were automated to call a physician's cell phone. This strategy led to 11% quicker treatment and reduced the duration of a dangerous condition by 29%.[60] Non-drug related alerts for inpatients have a variable success record. A computer-alert program at the Brigham and Women's Hospital alerted physicians about the risk of blood clots in legs and was able to show a substantial improvement in the preventive measures used, as well as a decrease in the actual number of blood clots reported in the legs and lungs compared to a group who did not receive alerts.[61] WakeMed Health and Hospitals created a robust library on their Intranet as decision support for IV drugs. They reasoned that making clinical content more accessible at the point of care would decrease pharmacy questions and promote evidence based nursing. They posted local hospital guidelines and standard drug information that used infobuttons to quickly link to content. A survey showed that 87% of nurses used the information and 95% believed the content improved productivity and efficiency.[62]

d) **Accurate Drug Histories**. The significance of having prior prescribing information available at the time a prescription is written should not be underestimated. Researchers at Henry Ford Health System reported a study in which clinicians were given six months of prescription claims data compared to a control group with no such information. Those with the additional information were more likely to change dosages (21% vs. 7%); add drugs (42% vs. 14%) and discontinue drugs (15% vs. 4%). Also, physicians with prior drug histories detected non-compliance in about 1/3 of patients versus none in the control group.[63] Another important issue concerning medication error reduction is the ability to reconcile all outpatient medications when a patient is admitted to a hospital. In many instances the information given by the patient is not correct. Lau reported that 61% of patients had at least one drug missing and 33% had two or more drugs missing on initial admission interview.[64] EHRs, HIOs and pharmacy claims data all offer the opportunity to provide additional patient drug history.

2. **Automated Inpatient Medication Dispensing Devices**

- Kept on nursing units
- Like ATM machines, these devices communicate with pharmacy computers and dispense medications stocked by the pharmacy
- User must have password to access
- Device keeps medication records
- Unfortunately, there is no evidence that these systems reduce errors or affect outcomes, in spite of their high price tag[65]

3. **Home electronic medication management systems**

- At least one company is in the process of developing an ATM-like machine to administer medications to the elderly at home
- Medications are loaded into the machine as a 6x9 inch blister pack with storage for up to 10 medications for one month
- The device is connected to the pharmacy via the Internet so they can monitor compliance and adjust doses
- The device (EMMA) gives a visual and audible alert when it is time to take a medication[66]

4. **Pharmacy Dispensing Robots**

- Studies suggest that robotic systems save space, decrease manpower, increase the speed to fill a prescription and decrease errors
- Robots are very helpful when there is a shortage of pharmacists or staff. Technology allows pharmacists to have more of a supervisory role
- Ideally, systems would receive electronic prescriptions from outpatient and inpatient areas, then be checked by both the EHR and the pharmacist, then labels are printed and the prescription filled[67]
- Robots are available in different models that handle a variety of drugs (50 to 200), giving pharmacies financial flexibility[68]

5. **Electronic Medication Administration Record (eMAR)**

- Electronic nature eliminates legibility issues
- There is no need to rewrite the MAR when medications are changed or discontinued

- No need to search for the patient's chart to see what medications the patient is on
- EMAR can provide allergy and timing alerts
- Application is available to nurses and others, like physicians making rounds
- Program can be web based and can be wireless[69]

6. **"Smart" Intravenous (IV) Infusion Pumps**

- Intravenous sedatives, insulin, anticoagulants and narcotics pose the highest risk of harm from medication errors[70]
- Early pump versions allowed for constant infusion rates without programmable alerts
- Smart pumps can be programmed to deliver the correct amount of IV drugs and are associated with drug libraries and alerts that the dose differs from hospital guidelines. This feature is known as a "dose error reduction system" (DERS). This would be particularly important if there were a decimal point error or the units of administration such as mg/hour were incorrect. The end result is that the infusion will not begin until the discrepancy is corrected
- It is estimated that 37% of hospitals are now using smart infusion pumps
- As an added benefit some pumps also wirelessly transmit data so that specific events can be captured and studied
- Smart pumps will eventually link to eMars, CPOE and pharmacy IT systems
- Evidence so far indicates that smart infusion pumps avert serious IV medication errors. It is important to realize that even a small reduction in errors that involve dangerous IV drugs is an important advance[71]
- In 2005 Rothschild et al reported on a controlled trial of smart infusion pumps in 744 cardiac surgery patients. They found that serious medication errors were unchanged compared to a control group. This was thought to be due to the fact that many nurses did not consult the drug library, alert overrides were common and there were many undocumented verbal orders. It would be important for hospitals to set the drug library as the default for the program. An unanticipated bonus of this program was the fact that the memory system of the infusion pump was a treasure trove of information, pointing out future areas of training and changes in nursing protocols[72]
- Recently a smart pump with built in bar coding was developed by Alaris[73]

7. **Calculators**

- Johns Hopkins University created a web based pediatric total parenteral (IV) nutrition (TPN) calculator and as a result reduced medication errors in half with an annual projected saving of $60-80,000
- The infusion calculator was associated with 83% fewer errors[74]
- Other web based and handheld medical calculators are available but little is known regarding their impact on patient safety

8. **Bar coding and RFID**

Bar Coding

Bar coded medication administration (BCMA) involves a variety of elements: bar code printers, scanners, a network (wired or wireless) to connect to a server, server with bar coding software and integration with the pharmacy information system and any CPOE system. A typical linear bar code is most common but newer two dimensional bar codes

exist that encode more information in a smaller space and can be read from different angles (figure 14.2).

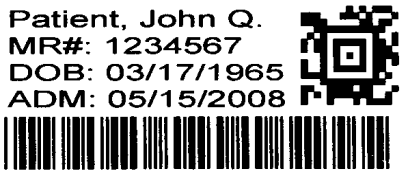

Figure 14.2 Bar coded label with 2-D code (Courtesy LaserBand)

Figure 14.3 Bar coded ID bracelets(courtesy ENDUR ID)

Figure 14.3 demonstrates a wrist band with linear bar coding and pictures of both the infant born in the hospital and the mother.

How does a BCMA system work?

- A standard scenario would be for a nurse to scan his/her ID bar code, the patient's bar code and the medication's bar code. This information could be sent wirelessly to the program server at which time the software determines that the correct medication is going to the correct patient at the correct time. In general, the system will generate a warning or an approval
- Studies have shown that about 35% of medication errors occur at the administration stage. Further breakdown of errors that might be prevented by BCMA include: dose omission (21%), wrong patient (4%), wrong time (4%), wrong route (1%)[75]
- Most healthcare organizations use three linear barcodes: codes 128, 39 and Reduced Space Symbology (RSS). Two dimensional barcodes are available that can store 3,000 characters of patient information
- Bar codes can be placed on patient ID bands, medications, vials of blood and transfusion bags
- FDA mandated that drug companies apply bar codes on unit dose medications and blood components by April 2006. Barcodes must contain the national drug code (NDC) that can be used to indentify medications
- The price tag is likely to be $300K- $1 million for hospitals to adopt barcode technology

- There are very few studies looking at patient outcomes with this technology. Poon et al studied dispensing errors before and after implementation of a BCMA at the Brigham and Women's Hospital Pharmacy. They demonstrated that the target dispensing error rate dropped by 0.25% to 0.018% (93 % relative risk reduction)[76]
- One study showed an error rate decrease from 1.0% to .2% and improvement in stock ordering time.[77]
- BCMA in an adult medical intensive care unit was reported in 2009. It had the potential to improve these standard drug errors: wrong drug, wrong administrative time, wrong route, wrong dose, omissions, administration of a drug with no order and documentation error. This study showed an improvement in only administration time after implementation of a BCMA system.[78]
- Veteran's Affair hospitals have had bar coding since 1999 in their 161 hospitals. Once scanned, the software confirms that the correct medication in the correct dose and frequency has been given to the correct patient. It also updates the electronic medication record. As a result of this technology one VA hospital was able to decrease medication errors by 66% over 5 years.[79]
- Bar coding is also used for laboratory specimen labeling. As an example, an inpatient's ID bracelet is scanned and it confirms that this patient requires a certain blood test. A mobile printer prints labels that are attached to the tube of blood at the bedside.[80] A study published in February 2008 from a Pediatric Oncology hospital demonstrated a decrease from 0.03% to 0.005% in mislabeling errors after one year of implementation. The incidence of unlabeled specimens continued to be the same, after implementation. There were a few misreads due to the curvature of the wrist band, that will likely be prevented with a 2 dimensional bar code band. They estimated that the cost of the system added $1.75 to each specimen processed.[81]
- Sutter Health implemented barcode medication administration at its 25 hospitals at a cost of $25 million. After one year there were: 28,000 medication mix-ups averted and 9% could have resulted in moderate to serious harm and 1% were life threatening.[82]
- Southwestern Vermont Health Care organization provided some valuable lessons learned in the May/June 2008 Patient Safety & Quality Healthcare magazine.[83]
- AHRQ has funded pilot programs in 11 states for bar coding. In spite of some successes they concluded that implementation is not easy.[84]
- Problems with BCMA include
    - High cost
    - Nurse work flow issues
    - Some meds need to be re-packaged in order to be read
    - Scanners are not interoperable so institutions may have to buy different scanners[85]
    - Koppel reported on the 15 types of "workarounds" hospitals develop to make BCMA work[86]

Radio Frequency Identification (RFID)

- Unlike bar coding, RFID can be read-only or read-write capable

- RFID tags can be read if wet or thru clothing. Better for blood and IV bags
- Drug companies and Walmart want RFID to record and track all inventory. They are also seeking to decrease the counterfeit drug market which may total $2 billion yearly[87]
- A scanner must interface with an established database to identify the object with the RFID tag
- Tags are cheap but transceivers (scanners) are expensive
- Scanners can be part of a PDA or laptop computer. A PDA with Socket CF reader-scan card can read RFID and bar codes[88]
- Tags can be active (needs battery, larger, more memory, longer range and more expensive) or passive (smaller, cheaper, short range and no battery)

Figure 14.4 Passive RFID tag on back of a drug label (courtesy CPTTM)

- RFID tags can be low, medium or high frequency
- RFID systems can track patients within a hospital with an active tag that works like a transmitter and gives location and time
- RFID tracking will allow for better business and time analysis
- RFID systems may replace or complement bar coding
- One company offers RF-scanning of the surgical patient before the wound is closed to be sure no surgical sponges are left in[89]
- In 2007 the Mayo clinic began to use passive RFID tags, attached to specimen bottles, used to hold GI endoscopy biopsies. The RFID system was provided by 3M and over 30,000 specimens have been processed. The RFID holds a unique patient number stored in a database that must match. The error rate prior to RFID was 9.2%/100 bottles and .55%/100 bottles after transition[90]
- A June 2008 article in JAMA raised concerns that when an active or passive RFID tag is read by the scanner it emits electromagnetic inference (EMI). They reported frequent potentially hazardous incidents in a non-clinical scenario when devices like pacemakers and ventilators were exposed to EMI, even at distances greater than 12 inches. Although they tested only RFID tags produced by two vendors, there should be a note of caution with all RFID devices around critical equipment[91]

Figure 14.5 demonstrates an implantable FDA approved RFID chip has been used in both humans and animals. The chip contains a 16 digit number that is read by

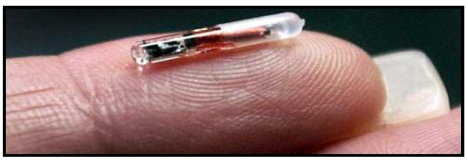

Figure 14.5 Implantable RFID chip (courtesy VeriChip)

a scanner. The number is used to locate the web based medical record. The market may be primarily for infants, the unconscious and the demented.[92]

9. **Medication Reconciliation**. It is well known that when patients move from hospital-to-hospital, from physician-to-physician or from floor-to-floor, medication errors are more likely to occur. Home medications are occasionally forgotten or incompletely recorded. The Joint Commission mandated in January 2006 that hospitals must reconcile a list of patient medications on admission, transfer and discharge. A report of "errors of transition" concluded the following:

    - 66% occurred at transition to another level of care e.g. ICU
    - 22% occurred on admission
    - 12% occurred on discharge[93]

    If all medical offices, pharmacies and hospitals had the same EHR or were connected to a shared health information organization, then the answer would be simpler and electronic. Instead, we find completely disparate systems that are not interoperable. Patients can compound the issue by using multiple pharmacies, taking alternative drugs and not keeping records. Multiple IT solutions are available but none are comprehensive because of the disparate process. Several IT initiatives are worth mentioning:

    - RelayHealth will offer IntegrateRx-Medication History as part of its patient portal and will be based on payer or pharmacy claims data. The system can be integrated with an EHR or e-prescribing program[94]
    - Standalone software programs such as MedsTracker have appeared on the scene and have the capability of communicating with an EHR. Once medications have been reconciled, at discharge a list can be given to patients and physicians and faxed to a pharmacy[95]
    - E-prescribing companies such as DrFirst will offer medication reconciliation in 2008, based on pharmacy claims data[96]
    - Healthcare systems such as Partners Healthcare will develop their own systems to be part of their EHRs. Only a minority of organizations have the ability to build an interoperable system[97]

    Although pharmacy claims data makes sense, it will not help the uninsured who do not have records. Also, many patients take herbal medications they fail to report and are not retrievable electronically.

10. **Electronic Prescribing**: to be covered in the next chapter

Key Points

- Patient safety is a major issue facing US Medicine today. Far too many people die from medical errors each year
- There is great hope that information technology, particularly clinical decision support as part of the electronic health record, will improve patient care and safety
- There is some evidence that clinical decision support and alerts may reduce medication errors
- Bar code medical administration also appears to reduce some medication related errors but is expensive and complicated
- Any modality that will reduce deadly intravenous drug errors, such as smart infusion pumps, makes sense
- A dedicated and focused patient safety strategy must accompany any deployment of information technology

Conclusion

Better studies are needed before we can expect widespread purchase and implementation of technology to improve patient safety. Until then, we will have to rely on anecdotal and limited studies. Surprisingly, there is not a universal database or method to store and analyze medical errors nationally.[98] Moreover, CEOs and CIOs will be looking for a reasonable return on investment. However, if improved patient safety means a larger market share, fewer law suits or a better hospital ranking by the state or federal government, then adoption will likely occur. According to HealthGrades, there is evidence that the highest ranked hospitals for quality have lower mortality rates.[99] Additionally, it appears that the most wired hospitals also have lower mortality rates but it is too early to establish clear-cut cause and effect.[100] One could also draw on the experience of the Veterans Affairs hospitals to show how their electronic health record has markedly improved the quality of care and efficiency.[101] Is their dramatic systemic improvement solely due to their EHR or is it due to the visionary Dr Kiser who saw the need for modernization and the establishment of a culture of quality and safety? A study by Menachemi et al published in December 2007 looked at 98 Florida hospitals' IT adoption and patient outcome measures and concluded there was a definite correlation. They felt that IT systems for clinicians provided up-to-date guidelines at the point of care. The relationship may be more complicated and involve more than just technology, such as the effects of better leadership, training, etc.[102]

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15

Electronic Prescribing

ROBERT E HOYT

Learning Objectives

After reading this chapter the reader should be able to:

- List the confirmed and potential benefits of electronic prescribing
- Identify the problems and limitations of handwritten prescriptions
- Describe the SureScripts and RxHub networks
- Enumerate the new Medicare reimbursement regulations for e-prescribing
- List the obstacles to widespread e-prescribing

The prescription shown in figure 15.1 resulted in a patient death as the pharmacist interpreted the drug prescribed as *Plendil* and not *Isordil*. This was the first medical malpractice case successfully prosecuted due to illegible handwriting. The jury awarded $450,000 in damages with 50% of responsibility on the cardiologist and 50% on the pharmacist.[1]

Cases such as this led the Institute for Safe Medication Practices (ISMP) to push to "eliminate handwritten prescriptions within three years". The ISMP points out that up to 7,000 Americans die each year due to medication errors resulting in a cost of about $77 billion annually.[2]

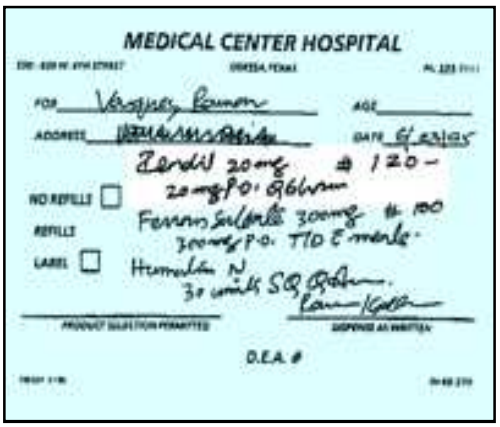


Figure 15.1 Illegible prescription

In 2006, the Institute of Medicine stated that all prescriptions should be electronic by the year 2010.[3] Since 2000, Delaware, Florida, Idaho, Washington, Montana, Tennessee, and Maryland have enacted laws requiring legible prescriptions. Montana fines up to $500 for each illegible script. Washington State took a further step by outlawing prescriptions written in cursive.[4]

Approximately 3 billion prescriptions are written yearly in the United States and of those only about 2-3% are electronic. On the surface this seems difficult to understand given the multiple advantages of e-prescribing:

- Legible and complete prescriptions that help eliminate handwriting errors and decrease pharmacy "callbacks" (150 million yearly) and rejected scripts (30%)[5]
- Abbreviations and unclear decimal points are avoided
- The wait to pick up prescriptions would be reduced
- Fewer duplicated prescriptions
- Better compliance with fewer drugs not filled or picked up
- Timely notification of drug alerts and updates
- Better use of generic or preferred drugs
- The ability to check plan-level and patient-level formulary status and patient copays
- E-prescribing can interface with practice and drug management software
- The process is secure and HIPAA compliant
- It is the HIT platform for future clinical decision support, alerts and reminders. It could integrate decision support related to both disease states and medications
- Digital records improve data analysis of prescribing habits
- Programs offer the ability to look up drug history, drug-drug interactions, allergies and compliance
- Provides a single view of prescriptions from multiple clinicians
- Program has the ability to check eligibility, co-pays and it can file drug insurance claims
- A 2005 study suggested that e-prescribing reduced labor costs $0.97 for a new prescription and $0.37 for a renewed prescription[6]

The Medical Group Management Association published an important report in 2004 documenting the time and money spent by physicians and staff to refill medications, verify proper formulary choices, etc. It demonstrated that non-electronic prescribing can be time intensive and expensive if you factor in the calls back and forth to a pharmacy for an average 10 man medical group:

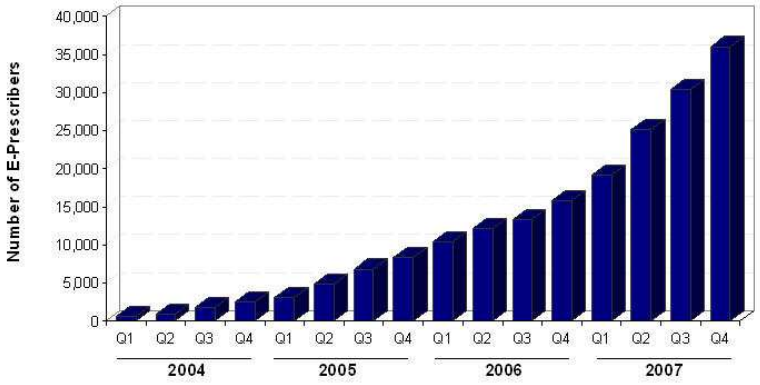
- An average of 7 phone calls per day; 63% of the time for refills
- An annual price tag of $157,000 for the time spent by the office staff and physicians to handle pharmacy related calls[7]

The Center for Information Technology Leadership's 2003 *Report on the Value of Computerized Physician Order Entry in Ambulatory Settings* estimated that e-prescribing would save $29 billion annually from fewer medication errors; reduced overuse, misuse and adverse drug event related hospitalizations and more cost effective selection of generic or less expensive medications.[8]

The concept of e-prescribing is gathering momentum in the United States and all states now approve eRx. Figure 15.2 shows the growth of e-prescribing in the United States through the year 2007 and according to SureScripts the number of clinicians using e-prescribing exceeding 100,000 Q1 2009.[9]

Perhaps one of the strongest driving forces behind e-prescribing was the Medicare Prescription Drug Improvement and Modernization Act (MMA) of 2003 that allocated about $50 million in 2007 to support e-prescribing systems and allowed health plans to offer incentives to adopt information technology. Congress also approved the exceptions that allowed for donations of e-prescribing technologies to physicians from hospitals and other entities. Initial standards for e-prescribing were in place by January 2006 when the Medicare prescription benefit began. Standards should be finalized in 2009.[10] Under this Act, prescription drug plans were required to offer e-prescribing, although the option was voluntary for physicians. This program has tremendous clout as 40% of all scripts written are covered by Medicare. The database created for this program would

be the largest ever related to prescribing. The Act also offered drug plans higher reimbursement for physicians who e-prescribe.[11-13]



Source: Pharmacy Health Information Exchange, operated by SureScripts (December 2007).

Figure 15.2 Number of e-prescribers by year and quarter (courtesy SureScripts)

In mid-2008 the Medicare Improvements for Patients and Providers Act (MIPPA) was passed that codified the following:

- Beginning in January 2009, clinicians who e-prescribe for Medicare patients will receive a 2% bonus for years 2009 and 2010; a 1% bonus in 2011 and 2012 and a 0.5% bonus in 2013
- For those clinicians who do not e-prescribe, Medicare would enact a penalty of 1% in 2012, 1.5% in 2013 and 2% thereafter
- It is estimated that this bonus would amount to roughly $1000-$4000 per year for the average clinician
- In order to be a "qualified" e-prescribing program the software must
    - Generate a complete active medication list electronically
    - Transmit prescriptions electronically and generate alerts for drug-drug interactions, etc
    - Provide information on lower cost alternatives
    - Provide information on tiered medications, patient eligibility and authorizations
    - Program must use the NCPDP Script 8.1 standard by April 2009
- Computer-generated faxes are approved until January 1, 2012. After that date, they must be truly electronic or carried by the patient or manually faxed
- To be eligible for the bonus you must use e-prescribing at least 50% of appropriate Medicare patients
- You must use G-codes as numerators and CPT codes as denominators, as explained on the Medicare e-prescribing web-site. The denominator CPT codes are fairly typical for outpatients such as 99214 and at least 10% of the clinician's total allowable Medicare charges must be associated with the CPT codes they list. In terms of G-codes, G8443 means that the clinician used e-prescribing on all of the prescriptions and G8445 means no prescriptions were generated during the encounter. This requirement may be removed in 2010[14]

All EHR systems certified in 2008 by CCHIT meet these requirements and they plan to certify standalone systems in 2009.[15] SureScripts-RxHub lists the standalone and EHR vendors who have certified products and the exact functionality that was certified on their web site.[16]

As pointed out in chapters 1 and 2, the HITECH Act, as part of the American Recovery and Reinvestment Act, will include reimbursement by Medicare and Medicaid for EHRs, starting in 2011. It seems likely that many clinicians will be looking for an EHR system that will include electronic prescribing.

E-prescribing is available in two modes: 1) a standalone software program installed on a PDA/smartphone, computer or available as a web-based application 2) eRx integrated into an electronic health record. The standalone choice is simpler, less expensive and easier to learn but the EHR mode offers greater patient information at the time of prescribing. In the case of the web-based application, your patient data resides on a remote server and not on your computer. Another point worth mentioning is, although an increase in e-prescribing is occurring, many clinicians choose to print out an electronic script and then fax it to a pharmacy, thus negating several of the benefits of electronic prescribing. To date, most EHR vendors offer this functionality.

In order for standalone e-prescribing to function well, patient lists need to be uploaded into the system so clinicians do not have to waste time manually inputting information for new patients at the time of e-prescribing. Patient lists can derive from practice management systems or a practice can pay for an interface to be built to upload practice patient demographics.

Pharmacy Health Information Network: E-prescribing networks discussed in the next two paragraphs, have been created that allow for new prescriptions and renewals to be sent electronically to the patient's pharmacy of choice.

SureScripts was founded in 2001 by the National Association of Chain Drug Stores (NACDS) and the National Community Pharmacists Association (NCPA) to improve the quality, safety and efficiency of the overall prescribing process. It seems likely that one of the strongest motivating forces behind this collaboration was the need to reduce the number of call backs by pharmacists, as they reduce the pharmacist's financial bottom line. The SureScripts Electronic Prescribing Network is the largest network to link electronic communications between pharmacies and physicians, allowing the electronic exchange of prescription information. About 90% of major pharmacy chains are certified to connect and about 50% of independent pharmacies in 2009. It is not known how many physicians have connectivity. In 2007 all 50 states and Washington DC connected to their network. SureScripts works with software companies that supply electronic health records (EHRs) and electronic prescribing applications to physician practices and pharmacy technology vendors to connect their solutions to the SureScripts Pharmacy Health Information Exchange. The network is free to physicians but pharmacies pay a small amount (21.5 cents per transaction) to the software vendor like DrFirst and they in turn pay SureScripts. Vendors cannot connect to the SureScripts Electronic Prescribing Network until they complete a certification process that establishes rules that safeguard the prescribing process, to include patient choice of pharmacy and physician choice of therapy. SureScripts does not sell, develop, or endorse software. Vendors are certified based on several services: e-prescribing, e-refills, Rx history, eligibility and formulary. In 2008 SureScripts created a web site directed at consumers for education about e-prescribing. It seems clear that most pharmacists and network providers like SureScripts are frustrated by the slow adoption of e-prescribing and have elected to go direct-to-consumer or DTC.[17] In mid-2007 SureScripts helped create the Center for Improving Medication Management with its membership including the American Academy of Family Physicians, The Medical Group Practice Association, Blue Cross/ Blue Shield, Humana and Intel. The Center promotes research into improved prescribing through technology.[18]

RxHub was created in 2001 by three of the leading pharmacy benefit manager (PBM) organizations: AdvancePCS (acquired by Caremark), Express Scripts, and Medco Health Solutions. These organizations are responsible for funding and administering drugs on behalf of insurance companies and employers in order to control costs. RxHub creates another network between physicians and pharmacies to route patient medication histories (based on claims data) and pharmacy benefit information to physicians. This helps determine if the patient is eligible to receive certain drugs based on the insurance plan. This network also provides the option of forwarding a prescription to one of the mail order pharmacies. RxHub MEDS is a separate program that makes outpatient prescription histories available for inpatient care.[19]

In July 2008 SureScripts and RxHub merged and are now called SureScripts-RxHub, in an effort to further the adoption of e-prescribing. [20]

E-Prescribing Initiatives

E-Script Pilot Study studied 100 physicians in the Washington, DC area using DrFirst software in 2005. 0.3% scripts generated serious drug interactions or allergy alerts. The study estimated an annual avoidance cost of $100,000 and an average savings to health plans of $29 per prescription filled due to improved use of generics and drugs of choice.[21]

Maryland Safety through Electronic Prescribing Initiative created a consortium of 27 health organizations. The goal was to expedite the adoption of electronic prescribing in order to reduce medication errors. They will use multiple training modalities such as conferences, workshops, etc.[22]

Wellpoint is a large US health plan covering 34 million members. They offered physicians either a free office automation package or a free e-prescribing system using Dell Axim PDAs. Only 2,700 physicians out of the 25,000 contacted signed up for the e-prescribing alternative. This outcome was a reminder that it is not enough to make a service free. You must provide training and physicians have to believe that in the long run it will save time or money for them or their patients.[23]

South East Michigan E-Prescribing Initiative. Three major auto makers have partnered with the three largest health insurers to promote e-prescribing. The project uses e-prescribing software including RxHub, hosted on PCs or PDAs. The goal is to eventually sign on 17,000 physicians. Hardware was not provided and it is unclear who will pay for the software.[24] Clinician satisfaction has been high and the program will be extended to 2009. An analysis of 3.3 million prescriptions in 2007 demonstrated:

- Alerts of potential drug reactions were sent for about 1/3 of prescriptions, with physicians changing 41% of prescriptions
- The program warned physicians on about 100,000 potential drug allergies
- When an alert stated that a drug was not on formulary, a physician changed the prescription almost 40% of the time
- 40% of clinicians only used e-prescribing
- With every 1 per cent shift to generic drugs General Motors saved almost $20 million[25]

Nevada Project. Sierra Health Services and Clark County Medical Society collaborated to provide Allscripts e-prescribing software for its 5,000 physicians, for free, for 10 years. Maintenance fees were waived for two years. According to one report, utilization of generic drugs has increased from

53% to 64% (estimated cost saving of $5 million). Although they state that medical errors are down, specifics were not provided.[26]

Tuft's Health Plan Experience 2001-2002. The study involved 226 network physicians and allied health providers. As a result of the initiative, 8.9 fewer safety errors per physician per year were reported. Cost saving of $.30-.40 per member per month (PMPM) due to the use of generics and preferred drugs were noted. Clinicians and office staff reported that e-prescribing saved as much as 2 hours per day for the doctor's office and up to one hour per day for the pharmacist.[27]

Massachusetts's e-Rx Collaborative. Program was formed by Blue Cross/Blue Shield, Tufts Health Plan and the Neighborhood Health Plan. Two e-prescribing vendors (Zix and DrFirst) provided a PDA or PC based program to about 3000 physicians, paid for by the Collaborative. Software works with a Pocket PC PDA using PocketScript or with a web based program on the desktop and can operate wired or wirelessly.[28]

Florida Medicaid has awarded a contract to drug reference company Gold Standard to provide PDAs with drug information. The program began in 2001 with 500 users with the goal of expansion to 3000 physicians. The program and PDAs were free to clinicians and features wireless technology. A major goal was to promote use of more cost effective drugs using a preferred formulary. It is important to note that the average cost for a one month supply of a generic drug is $22.79; whereas the average for a brand name drug is $77.29.[29] As a result, 39 states require a generic drug for Medicaid patients when available. Florida is the first state to provide PDAs at no cost to try to reduce Medicaid drug costs. It is anticipated that the program will pay for itself in approximately five years.[30-31] Mississippi has a similar program for Medicaid patients that has equipped 225 physicians with handheld e-prescribing devices. The state believes they are saving about $1.2 million in costs monthly as a result of the program.[32]

Florida Blue/Cross Blue Shield partnered with Prematics to offer free e-prescribing in their networks, as part of Availity (see chapter on Patient Informatics). Prematics is providing CarePrescribe® web-based or loaded on PDAs, as well as a printer, Internet connectivity and training at no cost to physicians.[33]

Horizon Blue/Cross Blue Shield of New Jersey partnered with three e-prescribing vendors to deliver eRx software to 665 physicians. To date, they have written over 400,000 prescriptions at a cost of over $5 million dollars to Horizon Blue Cross/Blue Shield. Results so far show a savings of 30-60 minutes daily for prescribers.[34]

AHRQ E-prescribing Pilot Studies. In 2005 CMS awarded 5 grants for pilot projects to test e-prescribing standards for the Medicare part D e-prescribing capability. The following were the grantees:

- Blue Cross/Blue Shield of New Jersey. Pilot study included a mail-order pharmacy and Walgreen's retail pharmacy
- Brigham and Women's Hospital that included clinicians using EHRs and CPOE
- Achieve, a technology vendor for long term care
- University Hospitals Health System and Ohio KePRO that studied 300 primary and specialty offices
- SureScripts that studied e-prescribing in several states

Conclusions from these studies, as of February 2008, were as follows:

- NCPDP formulary and benefits standard version 1.0 should be accepted; but was not used often
- Prescription fill status notification lets clinicians know if patients picked up their prescriptions. This standard was recommended but rarely used
- Prior authorization approves the rare drug that needs this authorization. The evaluation team did not recommend this standard
- Structured instructions (sig) was not felt to be ready due to lack of standards
- Data standard RxNorm was also not felt to be ready for deployment and needs further evaluation
- Prescribing by surrogates (nurses) is important [35-36]

National E-prescribing Patient Safety Initiative (NEPSI) was announced in early 2007 and represents one of the most significant e-prescribing initiatives thus far. In 2008 they had 11,000 licensed prescribers. They offer free web based e-prescribing software (eRx Now™) to every physician in the United States. The two main sponsors are Allscripts and Dell Computers. Other coalition partners include Google, Aetna, Cisco, Fujitsu, Intel, Microsoft, Sprint, WellPoint, Wolters Kluwer Health and others. The program includes important features like drug-drug interactions, benefit and formulary status information and only requires 15 minutes of training. Quest Diagnostics has joined the network such that lab work can be ordered and results returned. Prescription histories can be stored on Google Health or Microsoft HealthVault. In order to upload patient demographics for the entire practice, they offer the ability to upload patient data from a .csv file free or a fee-based service.[37-38]

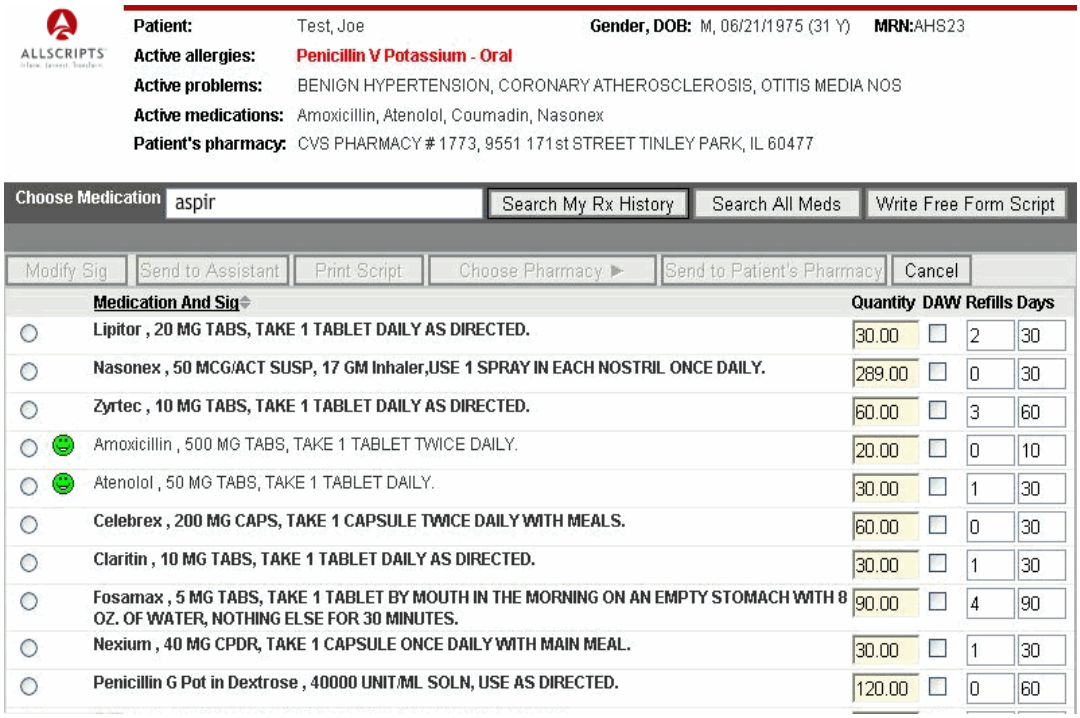

ALLSCRIPTS
Patient: Test, Joe
Gender, DOB: M, 06/21/1975 (31 Y)
MRN:AHS23
Active allergies: Penicillin V Potassium - Oral
Active problems: BENIGN HYPERTENSION, CORONARY ATHEROSCLEROSIS, OTITIS MEDIA NOS
Active medications: Amoxicillin, Atenolol, Coumadin, Nasonex
Patient's pharmacy: CVS PHARMACY # 1773, 9551 171st STREET TINLEY PARK, IL 60477
Choose Medication
aspir
Search My Rx History
Search All Meds
Write Free Form Script
Modify Sig
Send to Assistant
Print Script
Choose Pharmacy
Send to Patient's Pharmacy
Cancel
Medication And Sig
Quantity
DAW
Refills
Days
Lipitor , 20 MG TABS, TAKE 1 TABLET DAILY AS DIRECTED. 30.00 2 30
Nasonex , 50 MCG/ACT SUSP, 17 GM Inhaler,USE 1 SPRAY IN EACH NOSTRIL ONCE DAILY. 289.00 0 30
Zyrtec , 10 MG TABS, TAKE 1 TABLET DAILY AS DIRECTED. 60.00 3 60
Amoxicillin , 500 MG TABS, TAKE 1 TABLET TWICE DAILY. 20.00 0 10
Atenolol , 50 MG TABS, TAKE 1 TABLET DAILY. 30.00 1 30
Celebrex , 200 MG CAPS, TAKE 1 CAPSULE TWICE DAILY WITH MEALS. 60.00 0 30
Claritin , 10 MG TABS, TAKE 1 TABLET DAILY AS DIRECTED. 30.00 1 30
Fosamax , 5 MG TABS, TAKE 1 TABLET BY MOUTH IN THE MORNING ON AN EMPTY STOMACH WITH 8 OZ. OF WATER, NOTHING ELSE FOR 30 MINUTES. 90.00 4 90
Nexium , 40 MG CPDR, TAKE 1 CAPSULE ONCE DAILY WITH MAIN MEAL. 30.00 1 30
Penicillin G Pot in Dextrose , 40000 UNIT/ML SOLN, USE AS DIRECTED. 120.00 0 60

Figure 15.4 NEPSI e-prescribing program screen shot (Courtesy NEPSI)

Get RxConnected Initiative

- In March 2008 five physician groups launched a web site and campaign to promote e-prescribing
- It was created with the Center for Improving Medication Management
- The site gives technology guidance, physician testimonies and a list of connected pharmacies
- The site provides a readiness assessment; a free report on the status of their practice and connectivity to their pharmacies[39]

eHealth Initiative is a non-profit multi-stakeholder organization that tackles healthcare issues. They have a robust section on their web site on electronic prescribing. In October 2008 they published *A Clinician's Guide To Electronic Prescribing* that covers everything a clinician would need to get started. They also have monographs for payers and consumers that are very current and comprehensive.[40]

ePrescribe Florida was recently created to promote eRx in Florida in an effort to improve patient safety and increase use of generic medications. Its steering committee consists of Blue Cross/Blue Shield of Florida (BCBSF), Humana, AvMed, SureScripts-RxHub, Florida Academy of Family Physicians (FAFP), Florida Medical Association (FMA) and Walgreens.[41]

Electronic Prescribing Studies

The prescribing habits of 19 physicians using e-prescribing compared to a control group. Physicians first selected the likely diagnosis and they were then provided a list of recommended choices (clinical decision support) as well as links to evidence based resources. Drug costs were reduced by 11% compared to controls; but note that several of the authors were affiliated with one of the vendors.[42]

A medication error study reported in 2008 evaluated the effect of electronic prescribing on medication errors and adverse drug events (ADEs) in a systematic review with the following conclusions:

- 23 of the 25 studies analyzed showed a relative risk reduction in medication errors of 13%-99%
- 6 of the 9 studies that analyzed the effects on *potential* adverse drug events (injury) showed a relative risk reduction of 35%-98%
- 4 of 7 studies that analyzed the effects on adverse drug events showed a relative risk reduction of 30%-84%
- Although they concluded that e-prescribing can reduce medication errors and ADEs, better studies are needed[43]

Oregon Health and Science University compared handwritten versus computerized prescriptions in an emergency room setting. Computer written scripts were three times less likely to include errors and five times less likely to require a pharmacist's clarification. This resulted in a decrease in wait time for patients and call back time by pharmacists to physicians.[44]

Commercial E-prescribing study was published in 2007 in *Health Affairs* that reported on physicians' experiences using commercial e-prescribing systems in the time period from November 2005-March 2006. The following are some of its conclusions:

- Two thirds of the practices used the e-prescribing module of their EHR, so this article is less relevant to standalone e-prescribing programs
- It was a major effort to upload and maintain a complete medication list
- Most could not view medication records from other physicians
- There was little decision support available for prescribing
- Many had no access to formulary information
- Only the practices with standalone e-prescribing had pharmacy connections
- Many pharmacies were not ready for electronic transmission of prescriptions, to include faxes
- EHR e-prescribing modules required continued IT support to make it work
- Greatest time saving was for the renewal or refill of multiple medications
- It is assumed that many of their observations have since been corrected[45]

Brigham and Women's Hospital looked at the effect of electronic prescribing with formulary decision support on medication use and cost that was reported in December 2008. They concluded that e-prescribing increased the use of generic medications (tier 1) by 3.3%. The estimated that this would result in savings of about $845,000 per 100,000 patients treated yearly.[46]

Overrides of Medical Alerts in Ambulatory Care study was reported in 2009 in the *Archives of Internal Medicine*. They analyzed the safety alerts generated by over 2800 clinicians in three states who used a common e-prescribing system. Almost 7 percent of e-prescriptions generated alerts and clinicians accepted only 23% of allergy alerts and 9.2% of drug interaction alerts. Most clinicians viewed the alerts as a nuisance rather than an educational tool. In fact, clinicians accepted high severity alerts at about the same frequency as low severity alerts. They concluded that much work needs to be done with ambulatory e-prescribing alerts before there is widespread acceptance.[47]

Evaluation of e-prescribing by chain pharmacy staff study. Most studies have reported the benefits and limitations of e-prescribing from the clinician's perspective. This study evaluated 422 chain pharmacies located in six states by survey. Pharmacists and their staff reported that the safety, effectiveness and efficiency of patient care were somewhat improved but problems were also reported. Of the written comments, prescribing errors were the most commonly reported negative features. Selecting the wrong drug was the most common error (29%), followed by the wrong directions (28%). Delays in receiving the e-prescription was the second most commonly reported observation. They concluded with 11 recommendations; the most significant are as follows:

- Clinicians, not office staff should submit e-prescriptions
- Clinicians should use decision support when available
- Prescriptions should be bundled together for each patient (e.g. prescription 1 of 4)
- Pharmacists need an alerting mechanism to let them know an e-script has been received
- Pharmacy workflow should change so that e-scripts are not printed then again entered electronically
- Pharmacists should have the ability to electronically message the clinician for clarification as needed

- E-prescribing applications should have standard formats and procedures
- Patients need to be better educated about e-prescribing by office staff
- All parties should work to solve the issue of controlled drug prescriptions that currently cannot be sent electronically[48]

How to prepare for E-prescribing

The following are steps a clinician should take prior to adopting e-prescribing:

- Decide on standalone (Web, PC or PDA) or part of EHR. This might also depend on whether you see a large number of Medicare or Medicaid patients, as both e-prescribing and EHRs (chapter 2) will be reimbursable
- Be sure you check state and national e-prescribing initiatives that are either discounted or free, found on the SureScripts web site[49]
- Be certain the e-prescribing and/or EHR product is qualified or certified by Medicare regulations as noted earlier
- Review a Clinician's Guide to Electronic Prescribing [40] and/or SureScripts that will cover
    - Assessing your practice readiness
    - Defining your practice needs
    - Costs and financing options
    - Selecting a system
    - Deployment
    - SureScripts has a vendor matrix as well as a search engine for pharmacies ready for eRx[49]

E-Prescribing Obstacles and Issues

In spite of steady progress towards e-prescribing, adoption and implementation challenges remain:

- Adoption rate is still low but on the rise
- Will government support of eRx and EHRs be adequate in the short and long term? At this time physicians are reluctant to pay because they believe others such as pharmacists and PBMs benefit more from eRx. Implementation will also require training and upgrades of office technology to accommodate wireless transmission and other issues such as uploading patient demographics. Physicians don't want to lose time if eRx doesn't integrate with other office IT systems. Workflow and responsibilities will have to change to accommodate e-prescribing. Set up costs to upload patient demographics and IT support add to the cost
- Will the Joint Commission safety goal of medication reconciliation promulgate the use of eRx?
- E-prescribing with an EHR is superior to standalone applications because standalone applications tend to lack decision support. Regardless, many EHR e-prescribing programs still only generate a paper script or one that can be faxed to a pharmacy
- E-prescribing or eRx will eventually be part of all EHRs and part of Medicare/Medicaid reimbursement requirements

- E-prescribing is slower than paper scripts, but not when you factor in time spent calling back pharmacists or playing "phone tag"[50]
- Currently, controlled substances such as pain medications, which account for 10-20% of all prescriptions, cannot be ordered with e-prescribing due to DEA requirements. Ironically, they only accept written, faxed or verbal prescriptions. There is momentum to change this restriction and it is likely a final decision will be rendered by the FDA in late 2009[51]
- New errors have appeared due to the newness of electronic prescribing, in spite of them being legible[52]
- Will voice recognition, as part of e-prescribing, make the process faster? In 2008 MedVoice will partner with Nuance to create software for multiple mobile platforms. A sample dictation might be "*write a script for Jim Labowski; Zocor 20mg. Take each evening. Dispense 90, give three refills*"[53]
- Most authorities at this time have an attitude of cautious optimism[54]

Key Points

- Electronic prescribing has many advantages over paper prescriptions, yet the adoption of this technology has been slow for multiple reasons
- Electronic prescribing should decrease medication errors and be cost-effective overall for the average clinician
- Networks like SureScripts and RxHub exist to link clinicians, pharmacies and pharmacy benefit managers electronically
- Electronic prescribing will likely be aided by Medicare reimbursement for both e-prescribing in 2009 and electronic health records in 2011
- Obstacles such as who will pay for the software and integration with other office systems and incomplete pharmacy networks are a few of the known issues
- E-prescribing pilot projects should help generate data about the benefits and shortcomings of this new technology

Conclusion

E-prescribing as well as electronic networks between pharmacies and clinicians' offices are becoming a reality. Although the networks and prescribing software are readily available, not all of the pieces of the puzzle connect. Evidence so far indicates that e-prescribing should save time and money and hopefully result in improved patient safety. In March 2008 the normally skeptical Congressional Budget Office determined that if Medicare physicians were required to use e-prescribing then there would be a savings of $0.2 billion for the time period 2008-2013.[55] One can assume that the large increase in e-prescribers as of early 2009 is due to the federal government reimbursement plan but it is likely also due to the steady increase in adoption of technology in general. Will we see another spike in 2010-2011 as physicians make the decision to adopt EHRs for reimbursement?

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16

Telehealth and Telemedicine

ROBERT E HOYT

Learning Objectives

After reading this chapter the reader should be able to:

- State the difference between telehealth and telemedicine
- List the various types of telemedicine such as teleradiology and teleneurology
- List the potential benefits of telemedicine to patients and clinicians
- Identify the different means of transferring information with telemedicine such as store and forward
- Describe the concepts of home and hospital telemonitoring
- Enumerate the most significant ongoing telemedicine projects

According to the Office for the Advancement of Telehealth (OAT), Telehealth is defined as:

> *"the use of electronic information and telecommunications technologies to support long-distance clinical health care, patient and professional health-related education, public health and health administration"*[1]

Similar to the term e-health, telehealth is an extremely broad term. A review by Oh, et al found 51 definitions for e-health, suggesting that the term is too general to be useful.[2] One could argue that Health Information Organizations (HIOs), Picture Archiving and Communication Systems (PACS) and e-prescribing are also examples of telehealth if they exchange healthcare information between distant sites. Clearly, telehealth is the broader term that incorporates clinical and administrative transfer of information, whereas telemedicine relates to remote transfer of only clinical information. In this chapter we will use the term telemedicine instead of telehealth as we will be discussing the remote delivery of medical care. Telemedicine can be defined as:

> *"the use of medical information exchanged from one site to another via electronic communications to improve patients' health status"*[3]

Telemedicine was postulated in the 1920s when an author from Radio News magazine demonstrated how a doctor might examine a patient remotely using radio and television. Ironically this was proposed before television was even available.[4] (Figure 16.1) The first instance of remote monitoring has been attributed to monitoring the health of astronauts in space in the 1960's.[5] Telemedicine has been conducted using telephone communication for the past fifty years or more. With the advent of the Internet and video conferencing many new modes of communication are now available. Traditionally we have seen telemedicine arise to primarily communicate with remote rural or disadvantaged populations. This is largely due to shortages of specialists away from urban centers. The goal of telemedicine ultimately is to provide timely and high quality medical care remotely. In addition, telemedicine can result in high patient satisfaction due to better access to specialty care and less time lost from work.

Figure 16.1 Early Telemedicine (Courtesy Radio News)

Telemedicine Communication Modes

In this chapter we will mention multiple ways patients can receive remote care, starting from simple e-mail to complex video teleconferencing. In the past several years we have seen new telemedicine technologies and business models appear with more on the way. Table 16.1 shows several of the communication modes used in telemedicine, along with pros and cons.

Table 16.1 Telemedicine Communication Modes

Communication Mode	Pros	Cons
Patient-Portal secure-messaging	Asynchronous. Able to attach photos. Response can be formatted with template. Could use VoIP. Audit trail	Not as personal as live visit. Usually not connected to EHR or other information
Telephone	Widely available, simple and inexpensive	Not asynchronous. Unstructured. No audit trail
Audio-Video	Maximal input to clinician. Can include review of x-rays, etc. Perhaps more personal than just messaging	Currently, most expensive in terms of networks and hardware but that is changing

Telemedicine Transmission Modes

There are three major types of telemedicine transmission:

- **Store-and-forward.** Images or videos are saved and sent later. As an example, a primary care physician takes a picture of a rash with a digital camera and forwards it to a dermatologist to view when time permits. This method is commonly used for specialties like dermatology and radiology. This could also be referred to as asynchronous communication
- **Real time**. A specialist at a medical center views video images transmitted from a remote site and discusses the case with a physician. This requires more sophisticated equipment to send images real time and often involves two way interactive televisions. Telemedicine also

enables the sharing of images from peripheral devices such as stethoscopes, otoscopes, etc. This would be an example of synchronous communication

- **Remote monitoring**. A technique to monitor patients at home, in a nursing home or in a hospital for personal health information or disease management

Telemedicine Categories

We are going to arbitrarily divide Telemedicine into the categories noted below. It should be pointed out that virtual patient visits (e-visits) and patient portals could have been included in this chapter but we elected to keep them in the chapter on patient informatics.

- **Traditional Telemedicine**: Teleradiology, Teledermatology, Telecardiology, Telepathology, Telesurgery, Telepsychiatry, Teleneurology, Teleophthalmology, Telepharmacy, etc
- **Telerounding** of inpatients
- **Telehomecare and Telemanagement**

Traditional Telemedicine

Currently, in the United States there are over 200 telemedicine programs that are operational in 48 states.[6] Most programs consist of a central medical hub and several rural spokes. Programs attempt to improve access to services in rural and underserved areas, to include prisons. This reduces travel time and lowers the cost for specialists and patients alike. Programs have the potential to raise the quality of care delivered and help educate remote rural patients and physicians. The most commonly delivered services are mental health, dermatology, cardiology and orthopedics. Telemedicine can also be found in the international boating world where sailors can access a remote medical resource site. After registration they can call, fax or e-mail the site for advice on medical treatment while at sea.[7] Similarly, Virgin Atlantic Airlines will equip all of its aircraft with telemedicine devices for emergencies by the year 2009. Satellite technology will transmit the patient's vital signs to MedAire Centre in Arizona for interpretation by medical experts.[8]

- **Teleradiology**. The military has taken the lead in this area partly due to the high attrition rate of radiologists. By 2007 most Army x-rays became digital, which helped the storage, transmission and interpretation of images. With this newer technology a computerized tomography (CT) scan performed in Afghanistan can be read at the Army medical center in Landstuhl, Germany. Another example of military teleradiology can be found on the Navy hospital ships Mercy and Comfort where digital images can be transmitted to shore based medical centers. In the civilian sector, NightHawk Radiology Services help smaller hospitals by supplying Radiology services located in the United States, Switzerland and Australia. All are board certified; most trained in the United States and carry multiple state licenses. Currently, they cover 1350 hospitals in the USA. They list a staff of about 125 radiologists on their web site. The turnaround time for an image to be read is less than 30 minutes, using a large VPN service, with an average cost of $55. They offer conventional radiology as well as CT, MRI, Ultrasound and Nuclear Medicine interpretation.[9] Another more common but important example of teleradiology is the practice of radiologists reading films after-hours at home. They must have high resolution monitors and high speed connections to the Internet but with this set up and voice recognition software; they can be highly productive at home. This is becoming the standard practice for radiologists. Instead of driving in or staying at the hospital at night to interpret images, they can deliver interpretations while at home

- **Telesurgery**. The initial approach was to "telementor" surgeons performing operations in remote sites. In 2001 surgeons in New York were able to successfully perform laparoscopic cholecystectomies (gallbladder removal) on six pigs located in Strasbourg, France. This was followed one year later by the uneventful remote removal of the gallbladder in a 68 year old woman; the first case of telesurgery in a human[10]
- **Teleneurology**. Many regions lack neurologists to see patients with stroke-like symptoms to determine if they need clot-busting drugs (thrombolytics) or need to be transferred to a higher level of care. This is, in part, due to the increased malpractice risk and decreased reimbursement situation of treating emergency patients. With the advent of telemedicine, the case can be discussed real time and the patient and their x-rays can be viewed remotely by a stroke specialist. One company REACH Call Inc. developed a web based solution that includes a complete audio-visual package so Neurologists can view the patient and their head CT (CAT scan). REACH Call Inc. was developed by neurologists at the Medical College of Georgia. Because the program is web based, the physician can access the images from home or from the office. Likewise, the referring hospital only has to have an off-the-shelf web camera, a computer and broadband Internet connection.[11] Specialists-on-Call is a Massachusetts based organization that has 40 part time or full time Neurologists on board to handle emergency consults via telemedicine for about 60 private community hospitals. Their capabilities include the ability to transfer head CT images and bidirectional audio and video conferencing with remote physicians and families. To accomplish this they have an infrastructure that consists of a PACS, a call center, an electronic health record and videoconferencing equipment. The cost for this service is not inexpensive, for a 200 bed hospital, it would cost $400 per day and $40,000 for initial installation fees. It is unknown if third party payers will eventually reimburse for this service.[12-13] A Teleneurology study is reported later in this chapter.
- **Telepharmacy**. Like teleradiology, this field arose because of the shortage of pharmacists to review prescriptions. Vendors now sell systems with video cameras to allow pharmacists to approve prescriptions from a remote location. This is very important at small medical facilities or after-hours when there is not a pharmacist on location.[14] The North Dakota Telepharmacy Project operates 36 remote sites where pharmacy technicians receive approval for a drug by distant pharmacists via teleconferencing. In this manner a full drug inventory is possible even in small rural communities and the pharmacists still perform utilization reviews and other services remotely.[15]
- **Telepsychiatry**. Several studies have indicated that telepsychiatry is equivalent to face-to-face psychiatry for most patients.[16] The American Psychiatric Association promotes telepsychiatry, primarily for remote or underserved areas, using live video teleconferencing. During a telesession, there can be individual or group therapy, second opinions and medication reconciliation. In general, virtual visits help team medicine and patient satisfaction has been good. On the American Psychiatric Association web site, there is a listing of telepsychiatry programs and web resources covering reimbursement and other helpful topics.[17] Another trend that is appearing is telemedicine using free commercial-off-the-shelf (COTS) audiovisual programs such as Skype. Voyager Telepsychiatry uses this popular program to hold virtual telepsychiatry sessions.[18] One of the most important areas for telepsychiatry will involve military members who return from war with Posttraumatic Stress Disorder (PTSD) and Traumatic Brain Injury (TBI). About 40% of veterans live in rural areas, where transportation may be an issue. The VA has opened three Veterans Rural

Health Resource Centers in Iowa, Utah and Vermont to help develop and evaluate telemedicine programs.[19]

- **Teledermatology.** With the advent of good quality digital cameras and cell phones with medium quality cameras, the concept of teledermatology was born. The Teledermatology Project (http://telederm.org), created in 2002 has the goal of providing free worldwide dermatology expertise, particularly for third world countries and the underserved. Physicians can easily obtain a teleconsultation and diagnostic and therapeutic advice using the store and forward mode. A 2003 survey indicated that there were 62 teledermatology programs in the United States.[20-21] For more details on teledermatology, we recommend a very current e-Medicine article.[22]
- **E-Mail Teleconsultation**. Audio and video teleconferencing is not the only way to communicate between remote clinicians. The Army has established a Teleconsultation service for deployed military physicians, based on e-mail communication. The service is available 24/7 with most responses in 24 hours. Obviously, e-mail would be acceptable only for non-emergency cases. Almost every specialty is available to the military physician located in third world countries and the battlefield as part of the Office of the Surgeon General Teleconsultation Program[23]

Telerounding

This is a new concept developed to help address the shortage of physicians and nurses. Telerounding is being rolled out in facilities with reasonably good reviews in spite of obvious criticisms that it further compromises the already strained doctor-patient relationship.

- **Robot Rounds.** A study in 2005 in the Journal of the American Medical Association showed that surgeons could make a second set of rounds using a video camera at the patient's bedside (InTouch Robots). A physician assistant makes the actual rounds, backed up by the attending physician remotely via the robot. Robot units are 5 ½ feet tall, weigh 220 lbs and have a computer monitor as a head. The cost is more than $100,000 each or they can be leased for $5000 monthly plus $5000 per viewing station. At this time they are being used in 20 plus hospital systems in the United States. They can move around and can project x-ray results to the patient. Ellison et all reported on Urological patients who either received face-to-face rounds post-operatively or robotic telerounding. The concluded that robotic rounding was safe and well received by patients. Two-thirds of patients stated they would rather see their own physician remotely than a stanger making round in person. [24-26]
- ***E-ICU Rounding.*** In the United States it is predicted that we need approximately 35,000 intensivists (physicians who specialize in ICU care), but we only have 6,000. Moreover, in spite of the fact that hospital beds are not increasing, ICU beds are. Therefore, remote monitoring makes sense particularly during nighttime hours when physicians might not be present. The Leapfrog Group has advocated care delivered by intensivists for all ICUs as one of its four patient safety recommendations; but this goal remains elusive.[27] Hospitals that use e-ICUs tout the patient safety aspect but the financial savings may be just as significant. An e-ICU service will be less expensive than recruiting full time intensivists. Also, because ICU care can cost $2500 daily, any cost saving modality that positively affects length of stay or mortality will gain market attention. Avoiding law suits in the ICU also means a cost saving. In a study in 2004, monitors were placed in two large ICUs serving 2000+ patients over 2 years. ICU and hospital mortality and length of stay were compared before and after intervention. Patients were monitored remotely from 12 pm-7

am. The results showed that mortality was 9.4% compared to 12.9% for conventional care. The length of stay in the ICU was 3.63 days compared to 4.35 days for conventional care. It is estimated that over 100 hospitals now have e-ICU programs, even though there is no reimbursement by insurers.[28]

The leading vendor in this area is VISICU with about 150 customers. It was founded by two intensivists from Johns Hopkins in 1998. In December 2007 VISICU was purchased by Phillips Electronics Healthcare division which should lead to further implementation of e-ICU programs.

Sentara Healthcare System in Norfolk, Virginia reported a 27% decrease in ICU mortality, a 17% decrease in length of stay and a savings of $2,150 per patient using e-ICUs.[29] VISICU extended support of care outside the ICU in December 2007. Their plan is to use the eCareMobileTM unit to monitor sick patients on medical surgical floors, emergency departments, step down units and post anesthesia units. At Parkview Health in Fort Wayne Indiana, e-ICU physicians will assist rapid response teams that attend to deteriorating patients. Thus far, there has been a 32% reduction in floor-based cardiac arrests and improved nursing satisfaction.[30]

The cost for e-ICUs is considerable in spite of the potential benefits. The University of Massachusetts Memorial Health Care network spent $8 million to create a virtual ICU network to connect eight intensive care units. Specialists can now remotely view electronic health records, nursing notes, test results and video images of patients as well as access the latest clinical practice guidelines. They will soon add two-way video feeds so patients' families can communicate with specialists.[31] Sutter Health paid more than $25 million to establish its VISICU e-ICU system. Based on their analysis they have saved about $2.6 million in treatment costs by preventing deaths due to sepsis. In addition, they estimate that if sepsis is treated early, the ICU stay is shortened by four days.[32] Banner Health plans to expand the e-ICU concept to all of its 390 ICU beds by 2009. The e-ICU control center staff consists of 12 full time intensivists and one nurse for every 35 patients. Benefits of the program include improved nursing retention and a reduction in insurance costs of $1 million in the past year.[33] It is unfortunate that many understaffed rural hospitals will not be able to afford these services unless they are part of a larger network or there is reimbursement by insurers.

Cummings et al published the results from the University Health System Consortium Intensive Care Unit Telemedicine Task Force that reviews the subject and reports its consensus.[34] An interesting study was reported at the 2009 Society of Critical Care Medicine by Avera Health who reported the following results from a 30 month implementation of VISICU:

- Rural hospitals estimated a 37.5 percent reduction in the number of patients requiring transfer, representing a cost savings of more than $1.2 million
- Reduced length of stay in Intensive Care Units saved an estimated $8 million
- ICU and hospital mortality rates were 65-80 percent lower than predicted outcomes after implementation of the e-ICU, compared to 50 percent lower than predictions before implementation
- 90 percent of rural hospital clinical leaders surveyed reported being more comfortable caring for critically ill patients with e-ICU
- 90 percent of rural hospital leaders surveyed agreed that patients and families are comfortable staying in the hospital with the added e-ICU care

- 100 percent of rural physicians surveyed agreed that better, safer care can be supported by a remote critical care team[30]

Telehomecare and Telemanagement

At least 55 companies offer technology to monitor patients at home. Vital signs, weights, blood sugars, etc can be sent via a wired or wireless mode from homes to physicians' offices and databases. There are multiple reasons telemonitoring may catch on:

- Medicare changed reimbursement to home health agencies from the number of visits to a diagnoses based system, leading to decreased reimbursement for visiting nurses
- Telemonitoring programs allow for audio and visual contact with patients at home and therefore they can save a visit by a nurse or physician. Instead of nurses making routine home visits, then can make visits only if there is a problem, such as a change in symptoms or vital signs
- One consulting organization predicts a nursing shortage of 800,000 and a physician shortage of 85,000 to 200,000 by the year 2020[35]
- When "baby boomers" turn 65 they will be tech savvy and more likely to demand services like telemonitoring
- Monitoring may be possible using the ubiquitous cell phone
- Miniaturized biosensors may change the way we view telemonitoring
- Chronic illnesses are on the rise and will likely increase hospitalizations and readmissions, so any measure like home monitoring might decrease admissions. The goal is to intervene immediately rather than wait till the next appointment
- Linking home monitoring devices to EHRs and decision support will increase the functionality
- The potential to save costs is attractive but elusive and will require high quality confirmatory studies
- CMS will administer a Medicare Medical Home Demonstration project to test the "medical home" and "hospital at home" concepts. Medical groups will be paid for coordination of care, health information technology, secure e-mail and telephone consultation and remote monitoring. Details are preliminary and available on the CMS site.[36] For additional information on the medical home see the chapter on disease management

Health Buddy is an example of a popular home monitoring system with the following features:

- Data is sent via phone lines
- A FDA approved device that is certified by the National Committee for Quality Assurance
- Device comes with desktop decision support software
- Program could be part of a disease management program as it covers 45 disease protocols
- Device connects to a glucometer, BP machine, weight scales and peak flow meter for asthmatics
- Program is interactive with patients; it asks questions daily
- Used by the Veterans home telemedicine programs

- Health Buddy is used by over 12,000 patients and has been shown in one study (of limited design) to increase medication compliance and reduce outpatient visits[37-38]
- The Centers for Medicare and Medicaid Services will test the system:
- CMS will provide the system for 2,000 patients with chronic diseases in Oregon and Washington State
- Goal is to reduce medical costs by 5%[39]

HoneyWell HomMed

- Provides voice messages to patients in multiple languages
- Standard and optional features: digital weight scale, blood pressure, oximetry, glucometer, peak flow meter, blood tests (PT/INR), temperature and EKG
- Data is transmitted via phone lines
- LifeStream Connect™ is a new option that interfaces with EHRs
- Vendor has over 15,000 monitors currently in use and more than 300,000 patients have been monitored
- Monitor weighs < 3 lbs
- Cost is $3500 for monitoring system[40]

More Telemonitoring Systems

- MyCareTeam: a fee for service diabetic portal that stores data on Google Health www.mycareteam.com
- MediCompass: patient portal for diabetes, asthma and cardiovascular disease. Provides a dashboard view, a registry, an executive view and messaging www.medicompass.com
- Healthanywhere: allows for uploading of data by BlackBerry, home monitor and two way videoconferencing http://www.igeacare.com/HealthAnywhere/index.htm
- Intel Health Guide: Intel along with General Electric have entered the telehomecare market with a comprehensive program. At this time they are conducting pilot projects with Aetna, Erickson retirement communities and Scan Health Plan. The proposed system will include interactive software, a multimedia library, two-way video conferencing, home device uploads and patient alerts/reminders http://www.intel.com/healthcare/ps/healthguide/index.htm

Telemanagement

More and more companies are developing home monitors and sensors that will transmit information to a physician's office or other healthcare organization. They perceive an increased need based on our graying population, more chronic diseases and expensive home care. Programs will be interactive and include patient education for issues such as drug compliance. This data may interface with an electronic health record, information system or web site for others to evaluate. Some predict that houses will be wired with multiple small sensors known as "motes" that will monitor daily activities such as taking medications and leaving the house. The information would be transmitted to a central organization that would notify the patient and/or family if there was non-compliance or a worrisome trend. At this point the patient or families will have to pay for the systems. Some have already complained about the perceived lack of privacy and the potential for too many alerts or alarms.[41-43] There is some evidence that telemanagement can result in improved outcomes and cost savings, particularly in patients with diabetes, heart failure and chronic

obstructive lung disease. In a monograph by the Medical College of Georgia, prepared for the Advanced Medical Technology Association, they reviewed the medical evidence for telemedicine and telemanagement. Studies suggest that these technologies can reduce hospitalizations, emergency room visits and pharmacy utilization, thus paying for the technology. As they point out for telehomecare to be successful you must have adequate broadband access, reimbursement for physicians and nurses and financial resources to acquire and maintain the necessary medical technologies.[44] From the author's viewpoint, the majority of studies published thus far are lacking for one reason or another. It has not been determined unequivocally that home monitoring provides a reasonable return on investment or keeps patients out of the hospital or emergency room.

Telemedicine Projects

The following provides a sampling of some interesting projects:

- Informatics for Diabetes Education and Telemedicine (IDEATel): The largest government sponsored telemedicine program in the US. The project evaluated approximately 1650 computer illiterate patients living in urban and rural New York State. Patients received a home telemedicine unit that consisted of a computer with video conferencing capability, access to a web portal for secure messaging and education and the ability to upload glucose and blood pressure data. These same subjects were assigned a case manager who was under the supervision of a diabetic specialist. They used the Veterans Affairs clinical practice guidelines on diabetes. They were compared to a control group that didn't receive the home monitoring system. The results of this project are reported in the next section[45]
- Georgia Telemedicine Network: The first state-wide effort to link 36 rural hospitals and clinics with specialists at eleven large urban hospitals. Project created partnerships among Wellpoint (Blue Cross/Blue Shield) and the state government. Importantly, telemedicine consults were reimbursed as office visits due to a new Georgia law and 20 specialties were felt to be appropriate for telemedicine[46-47]
- University of Texas Medical Branch at Galveston: Program is the largest telemedicine system in the world with 300 locations and 60,000 annual telemedicine sessions. Sixty per cent of visits deal with a prison population. They also offer specialty services in neurology, addiction medicine and psychiatry[48]
- VA Rocky Mountain Healthcare Network: In Colorado veterans with heart failure, diabetes and emphysema were enrolled in a telemedicine program. The VA reported a 53% reduction in hospital stays resulting in a $508,000 savings overall. Outpatient visits dropped 52% and overall estimated savings of the program was $1.2 million dollars[49]
- Intel Telemedicine: Project will provide the real time video technology to service 105 rural clinics and hospitals for the municipal government of Zhanjiang, China[50]
- Teleburn Project: University of Utah Burn Center used telemedicine to treat burn patients in three states. Specialists can view videos or digital photos of burn patients for initial determination or follow up. The demonstration project was funded by the Department of Commerce[51]
- TeleKidcare: Urban project operated by the Kansas University Medical Center to deliver care at school so that children do not have to leave school to receive medical care. Reasons for televisits include: 47% ear, nose and throat problems, 31% for behavioral problems and

10% for eye related problems. In spite of private and government support they do not have a long term business plan for sustainability[52]

- TelePediatrics and TeleDentistry: The University of Rochester created the Health-e-Access program in 2001. The program was initially set up to connect pediatricians to inner city child care centers and elementary schools using telemedicine and two-way video conferencing via the Internet. The program has allowed the children and their parents to not leave the centers or their jobs. The program was started by grants but insurers have been willing to cover this initiative, presumably because it cuts down on emergency room visits. The director of the project has stated that he believes about 28% of pediatric visits to the emergency room in upstate New York could have been treated with telemedicine[53]
- Veteran's Teleretinal Program: Since 2000 the Veterans Health Affairs has operated a VHA Teleretinal Imaging project at 104 sites. Because 20% of veterans have diabetes they felt they had to conduct retinal screening for diabetic damage even though they might not have retinal experts at each clinic. They took high resolution retinal images and "stored and forwarded" them to ophthalmologists who would later made a determination[54]
- California Central Valley Teleretinal Program: Using a non-proprietary, open source web based program (EyePACS) images can be forwarded to an ophthalmologist for interpretation. Images are stored on a SQL Server and images are viewed with a web browser. A simple software program on the PC allows for uploading images to the server. There is e-mail notification to the consultant and back to the individual who sent the images. California will expand the program from the Central Valley to the entire state to serve 100 clinics and approximately 100,000 patients[55-56]
- Colorado Telehealth Network: is funded by the FCC to create the largest statewide fiber optic broadband network in the US. As of 2008, 72 hospitals, 118 clinics and 184 mental health clinics plan to participate[57]
- Federal Communications Commission (FCC): In 2006 they announced a $400 million budget for pilot projects to promote broadband networks in rural areas. The goal is to create networks for public healthcare organizations and non-profit clinicians that will eventually connect to a national backbone. The network could be used for telemedicine or other medical functions in rural areas. In November 2007 the FCC confirmed that $417 million over three years would fund pilot projects that would connect more than 6,000 hospitals, research centers, universities and clinics. The FCC will pay up to 85% of the cost to design, engineer and construct the networks. Internet2 or the LambdaRail Network will be used. Many of the projects will involve multi-state areas and most will enhance telemedicine. Much of the funding will come from the Universal Service Fund that derives from a fee added to consumers and telecommunication companies.[58] It is hoped that this ongoing fund could support projects long term and not just the initial development. The New England Telehealth Consortium announced in January 2008 that it will use the $24.7 million in FCC grant money to link 555 clinics, physician offices, hospitals, public health offices and universities in Maine, Vermont and New Hampshire. The network will act like a second Internet to allow the transmission of records and x-rays and the creation of videoconferences[59]

What the evidence shows

- A 2001 systematic review of telemedicine by Roine et al looked at reported patient outcomes, administrative changes or economic assessments. Of 1124 potential articles, 50 were felt to fit criteria for review. Most of the studies reviewed pilot projects and were of low quality. They felt that teleradiology, teleneurosurgery (looking at head CT scans before transfer), telepsychiatry, the transmission of echocardiograms, the use of electronic referrals to enable e-mail consultations and video teleconferencing between primary and secondary clinicians had merit. They also felt that it was impossible to state the economic value of telemedicine based on current evidence [60]
- The US Department of Veterans Affairs operates perhaps the largest telehomecare networks in the world (37,500 patients as of 2009). This is partly due to the fact that the VA has transitioned from inpatient to outpatient and home care. Also, with so many active duty members returning injured from the war zone they will eventually need telehomecare. Their Care Coordination/Home Telehealth program is also a disease management program. The VA currently runs three programs: telehomecare, teleretinal and a video teleconferencing services that links 110 hospitals and 380 clinics. Data from home devices inputs into the VA's EHR.[61] A study of 17000 VA home telehealth patients was reported in late 2008. Although the cost per patient averaged $1600, it was considerably less expensive than in-home care. They utilized individual care coordinators who each managed a panel of 100-150 general medical patients or 90 patients with mental health related issues. They promoted self management, aided by secure messaging systems and a major goal was early detection of a problem to prevent an unnecessary visit to the clinic or emergency room. 48% were monitored for diabetes, 40% for hypertension, 25% for heart failure, 12% for emphysema and 1% for PTSD. Patient satisfaction was very high. This study showed a 25% reduction in the average number of days hospitalized and a 19% reduction in hospitalizations[62]
- The Electronic Communications and Home Blood Pressure Monitoring study compared home blood pressure (BP) monitoring along with a BP Web portal, with and without the assistance of a pharmacist. The web portal was integrated with an enterprise EHR. In the group that received assistance from the online pharmacist, they showed significantly more patients achieving control than those who were monitored and had web portal access but no interaction with a pharmacist. Results might not pertain to other diseases and requires patients to have Internet access and pharmacists to be able to have EHR access[63]
- Web-based care for diabetes was evaluated by the same group (Group Health) who evaluated hypertension control above. They compared a group of Type 2 diabetes who received "usual care" with another group who had access to a web portal linked to an EHR. The web-based program included secure e-mail messaging with clinicians, feedback on blood sugar results, educational web resources and an interactive online diary to record diet, etc. After one year the control of diabetes, based on a glycated hemoglobin was marginally better (decrease of .7%) but there was no difference in blood pressure or cholesterol control between the two groups. There was no correlation between improvement and the number of times the web portal was accessed. They only used one care manager so it is unknown if their results would have been different with multiple care managers[64]
- Group Health conducted another study of 1,500+ diabetics aged >18 years old to determine if those who used secure messaging with their clinician had better blood sugar, blood pressure and cholesterol control. Only 19% of patients chose to message their physician.

Those that did had better blood sugar control, but not better control of blood pressure or cholesterol but had a higher rate of outpatient visits. Patients were not randomized for this study and the study was not prospective, so results are more difficult to interpret[65]

- The one year results of the IDEA TEL were published in late 2007 and showed mild improvement in blood sugars, cholesterol and blood pressure compared to the control project. Patient and physician satisfaction were positive but detailed cost data was lacking. Ironically, Medicare claims were higher in the study patients than in the control group, for unclear reasons.[66] The five year results were published in 2009 and although they showed some statistically significant improvement in blood sugar, cholesterol and blood pressure control, they were of doubtful clinical significance. Importantly, no financial information was offered and the users of this technology had a dropout rate greater than 50%.[67]At this point, it seems premature for a healthcare system to provide patients with a home computer and Internet access without clear cut medical or financial benefit
- Teleneurology or telestroke care was evaluated by a study by Meyer in 2008. They compared the outcomes of patients with a possible impending stroke and consultation by telephone, versus full video teleconferencing. Correct treatment decisions were made more frequently (98% versus 82%) for the teleconferencing sessions, but patient outcomes were the same. There was no difference in death rates or hemorrhaging after the clot busting drugs (thrombolytics) were administered.[68] An excellent review article on stroke telemedicine was published by Demaerschalle et al in the January 2009 issue of the *Mayo Clinic Proceedings*.[69] The jury is out whether stroke telemedicine is cost effective or a reasonable choice, compared to telephonic consultation[70]
- In spite of the many potential virtues of the e-ICU, a 2009 article by Berenson et al expressed the opinion that the actual value of e-ICUs was far from proven and there was a major interoperability issue between the e-ICU software and critical ICU systems like IV fluids and mechanical ventilation[71]

Telehealth Organizations and Research

- Office for the Advancement of Telehealth (OAT): falls under Health Resources and Services Administration (HRSA) that is an agency of the Department of Health and Human Services. Its goal is to promote telemedicine in rural/underserved populations, provide grants, technical assistance and "best practices"[1]
- American Telemedicine Association (ATA): a non-profit international organization with paid membership that began in 1993. Goals of the ATA are as follows:
    - *"Educating government about telemedicine as an essential component in the delivery of modern medical care*
    - *Serving as a clearinghouse for telemedicine information and services*
    - *Fostering networking and collaboration among interests in medicine and technology*
    - *Promoting research and education including the sponsorship of scientific educational meetings and the Telemedicine and e-Health Journal*
    - *Spearheading the development of appropriate clinical and industry policies and standards"*[3]

- USDA Rural Development Telecommunications Program. The USDA has a program to finance the rural telecommunications infrastructure. In 2007 there were grants and loans totaling $128 million to achieve the goals of broadband access for distant learning and remote medical care. The USDA Rural Development agency has funded several e-ICU programs in the US, including the study by Avera Health noted above.[72] As mentioned in chapter 1, the stimulus package should add $2.5 billion for USDA's Distance Learning, Telemedicine and Broadband Program
- The Agency for Healthcare Research and Quality has funded a number of telemedicine projects looking at virtual ICUs, telewound projects, cancer management, medication management, heart failure management and others[73]

Barriers to Telemedicine

- Limited reimbursement. Most telemedicine networks are created with federal grants. Medicare will reimburse if there is a formal consultation linked by live 2-way video teleconferencing and the patient resides in a professional shortage area. Medicaid at the federal level does not reimburse for telemedicine.[74] Medicare will reimburse physicians, nurse practitioners, physician assistants, nurse midwives, clinical nurse specialists, clinical psychologists and clinical social workers.[75] Many private insurers don't cover telemedicine, but a few provide the same coverage as a face-to-face visit
- Slow clinical acceptance because of the newness of the technology, limited reimbursement, etc
- Limited research showing reasonable benefit and return on investment
- High cost or the limited availability of high speed telecommunications
- Bandwidth issues, particularly in rural areas where telemedicine is most needed. VPN connections slow the process further
- High resolution images or video require significant bandwidth, particularly if x-rays or images or pills have to be read by remote clinician. Telepsychiatry may require lower resolution
- State licensure laws when telemedicine crosses state borders. Some states require participating physicians to have the same state license
- Lack of standards
- Lack of evaluation by a certifying organization
- Fear of malpractice as a result of telemedicine
- Sustainability is a concern due to an inadequate long term business plan

Key Points

- Telehealth is a neologism that relates to long distance clinical care, education and administration
- Telemedicine refers to the remote practice of medicine using technology
- Almost all specialties now have telemedicine initiatives
- In spite of the lack of reimbursement, virtual ICUs have gained in popularity because they may reduce mortality and length of stay
- Telehomecare is a new telehealth initiative that has appeared due to the graying of the US population and the increase in chronic diseases
- Lack of uniform reimbursement, lack of standards and lack of high quality outcome studies have impacted the adoption of telemedicine

Conclusion

Telemedicine is still in its infancy in most areas of the country. The barriers are largely financial due to the high cost to set up the system and the lack of reimbursement in many cases. Fortunately, the price of telemedicine systems is dropping so it may eventually be cheaper to use telemedicine in rural areas than to refer patients to distant urban specialists. As is common with other informatics areas, there continues to be overly optimistic hype. In a late 2007 monograph The Center for Information Technology Leadership maintained that implementation of nationwide telemedicine will reach a breakeven point in 5 years with a total annual net benefit of $4.28 billion. Their predictions are based on models and not actual studies.[76] If the FCC initiative is successful and/or HIOs flourish, we may then have the infrastructure required for telemedicine throughout the United States. Transmission of large images and the ability to compare old and new imaging studies will be greatly aided by Internet2 or the LambdaRail. If future studies prove there is substantial return on investment then it is a matter of time before more payers support telemedicine. As with other areas of Medical Informatics, studies tend to show improvement in patient care only if it is combined with human supervision. Further down the road as we gain more experience we might need less human intervention.

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17

Picture Archiving and Communication Systems (PACS)

ROBERT E HOYT

Learning Objectives

After reading this chapter the reader should be able to:

- Describe the history behind digital radiology and the creation of picture archiving and communication systems
- Enumerate the benefits of digital radiology to clinicians, patients and hospitals
- List the challenges facing the adoption of picture archiving and communication systems
- Describe the difference between computed and digital radiology

The following is a detailed definition of PACS:

> *"Systems that facilitate image viewing at diagnostic, reporting, consultation, and remote computer workstations, as well as archiving of pictures on magnetic or optical media using short or long-term storage devices. PACS allow communication using local or wide-area networks, public communications services, systems that include modality interfaces, and gateways to healthcare facility and departmental information systems."*[1]

PACS History

- The first reference to PACS occurred in 1979 when Dr Lemke in Berlin published an article describing a similar concept
- The work on the radiology data standard DICOM began in 1983 by a team lead by Dr Steven Horii at the University of Pennsylvania
- Digital imaging appeared in the early 1970's by pioneers such as Dr. Sol Nudelman and Dr. Paul Capp
- The University of Maryland hospital system was the first to go "filmless" in 1999
- The father of PACS in the United States is felt to be Andre Duerinckx MD PhD[2]

Many hospitals and radiology groups are making the transition from analog to digital radiography. To their credit, radiologists have pushed for this change for years but have had to wait for better technology and financial support from their healthcare organizations. We are now at a point where the technology is mature but the financing is still an issue. Moreover, with the ongoing introduction of electronic health records (EHRs) in many health care organizations, there is a need to integrate EHRs with hospital information systems (HISs) and radiology information systems (RISs). The Veterans Health Administration will launch a nationwide teleradiology network in 2009 that will interface with its EHR VistA. All images will be sent to a server in California that all VA

radiologists can access. The future challenge of teleradiology, therefore, is to share PACS images among disparate healthcare organizations. The Department of Defense is planning for a similar multifacility PACS solution in the near future.[3]

PACS Basics

- Initially, hospitals purchased film digitizers so routine x-rays could be converted to the digital format
- Now digital images go from the scanning device directly into the PACS
- PACS usually has a central server that serves as the image repository and multiple client computers linked with a local or wide area network (LAN or WAN)
- Images are stored using the Digital Imaging and Communications in Medicine (DICOM) standard (see chapter 4 on Interoperability)
- PACS is made possible by faster processors, higher capacity disk drives, higher resolution monitors, more robust hospital information systems, better servers and faster network speeds. PACS is also integrated with voice recognition systems to expedite report turnaround
- Input into PACS can also occur from a DICOM compliant CD or DVD brought from another facility or teleradiology site via satellite
- Most diagnostic monitors are still grayscale as they have better resolution (3-5 megapixels), compared to color. Newer "medical monitors" have 2,048 x 2,560 pixel resolution and can display 1000+ shades of grey instead of the 250 shades of grey seen on a standard desktop monitor
- PACS is now important for Cardiologist who perform image producing procedures
- It is estimated that about 90% of large teaching hospitals have PACS but usage by small community hospitals is far lower [4-5]
- PACS was initially associated with expensive work stations ($50K) using thick client technology. Now the trend is for thin or smart clients that permit clinicians to access PACS via a web browser from the office or home [6]

PACS Key Components (Figure 17.1)

- **Digital acquisition devices**: the devices that are the sources of the images. Digital angiography, fluoroscopy and mammography are the newcomers to PACS
- **The Network**: ties the PACS components together
- **Database server:** high speed and robust central computer to process information
- **Archival server:** responsible for storing images. A server enables short term (fast retrieval) and long term (slower retrieval) storage
- **Radiology Information system (RIS)**: system that maintains patient demographics, scheduling, billing information and interpretations
- **Workstation or soft copy display:** contains the software and hardware to access the PACS. Replaces the standard light box or view box [7]

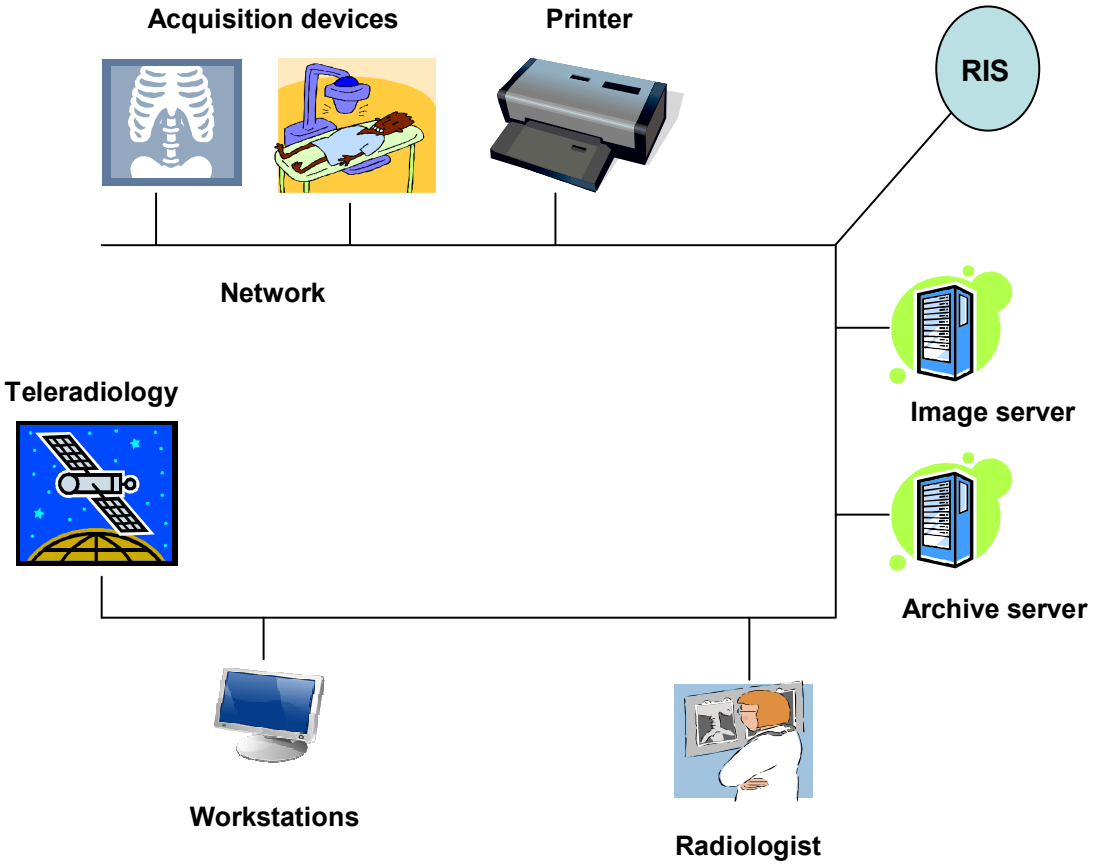

Figure 17.1 PACS Components

Types of digital detectors

1. Computed radiography (CR): after x-ray exposure to a special cassette, a laser reader scans the image and converts it to a digital image. The image is erased on the cassette so it can be used repeatedly.[7] (Fig.17.2)

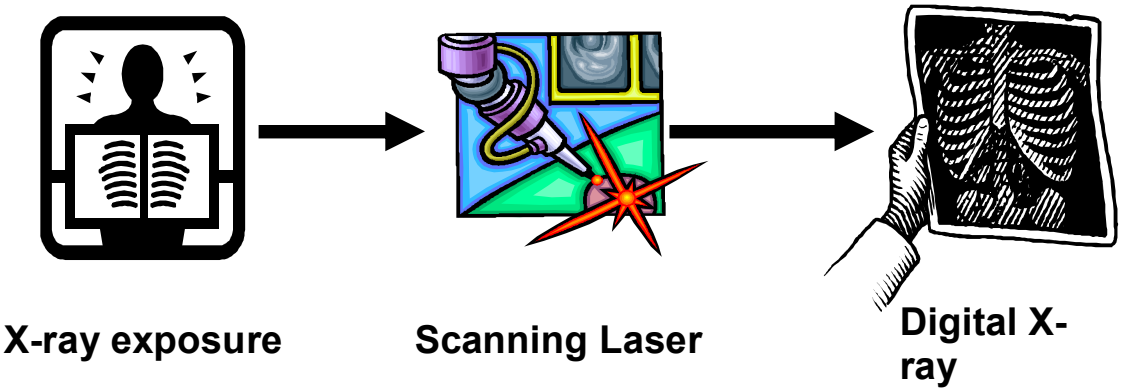

Figure 17.2 Computed Radiography

2. Digital radiography (DR): does not require an intermediate step of laser scanning.[7]
   It is important to note that many facilities with digital systems or PACS still print hard copies or have some non-digital services. This could be due to physician resistance, lack of resources or the fact that it has taken longer for certain imaging services such as mammography to go digital. *Full PACS* means that images are processed from ultrasonography (US), magnetic resonance imaging (MRI), positron emission tomography (PET), computed tomography (CT) and routine radiography. *Mini-PACS*, on the other hand, is more limited and processes images from only one modality.[8]

Example of PACS Available on a Hospital Desktop Computer

The following chest x-ray (Figure 17.3) was retrieved from the AGFA IMPAX 6.3 PACS, a client-server web-based system.[9] The PACS receives HL7 messages from the hospital information system (HIS) and provides diagnostic reports and other clinical notes along with the patient's images. Although resolution is slightly better with special monitors, the quality of the images on the standard desktop monitor is very acceptable for non-diagnostic viewing. Any physician on the network can rapidly retrieve and view standard radiographs, CT scans and ultrasounds. **Scenario #1**: An elderly man is seen in the emergency room at the medical center over the weekend for congestive heart failure and is now in your office on a Monday morning requesting follow up. Your practice is part of the Wonderful Medicine Health Organization so you pull up his chest x-ray on your office PC and determine how much fluid was present on x-ray. **Scenario #2**: You are seeing a patient visiting your area with a cough and on his chest x-ray you note the patient has a mass in his left lung. You download this image on a CD (or USB drive) for the patient to take to his distant PCM where he will receive a further work up. The desktop program is intuitive with the following features:

- Zoom-in feature for close-up detail
- Ability to rotate images in any direction
- Text button to see the report
- Mark-up tool that does the following to the image:
  - Adds text
  - Has a caliper to measure the size of an object
  - Has a caliper to measure the ratio of objects: such as the heart width compared to the thorax width
  - Measures the angle: angle of a fracture
  - Measures the square area of a mass or region
  - Adds an arrow
- Right click on the image and short cut tools appear
- Export an image to any of the following destinations:
  - Teaching file
  - CD-ROM
  - Hard drive, USB drive or save on clipboard
  - Create an AVI movie

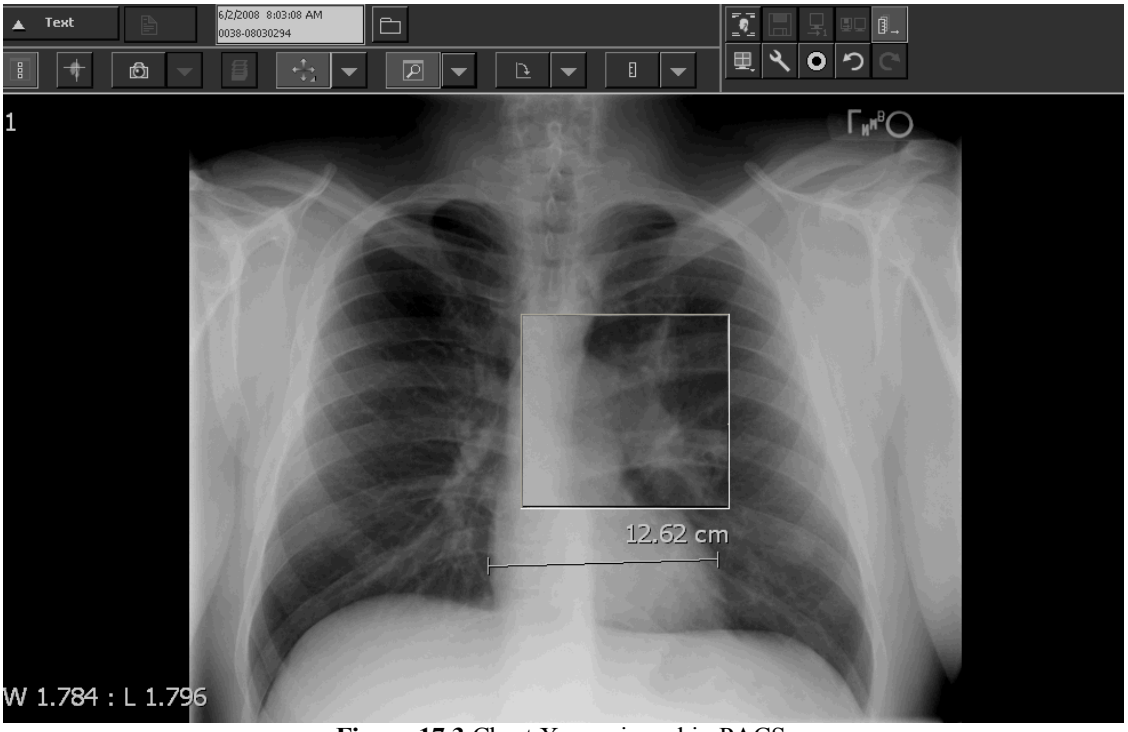

Figure 17.3 Chest X-ray viewed in PACS

PACS Advantages and Disadvantages

PACS advantages

- Replaces a standard x-ray film archive which means a much smaller x-ray storage space. Space can be converted into revenue generating services and it reduces the need for file clerks
- Allows for remote viewing and reporting; to also include teleradiology
- Expedites the incorporation of medical images into an electronic health record
- Images can be archived and transported on portable media; USB drive and Apple's *i*Phone [10]
- Other specialties that generate images may join PACS such as cardiologists, ophthalmologists, gastroenterologists and dermatologists
- PACS can be web based and use "service oriented architecture" such that each image has its own URL. This would allow access to images from multiple hospitals in a network
- Unlike conventional x-rays, digital films have a zoom feature and can be manipulated in innumerable ways
- Improves productivity by allowing multiple clinicians to view the same image from different locations
- Rapid retrieval of digital images for interpretation and comparison with previous studies
- Radiologists can view an image back and forth like a movie, known as "stack mode"
- Quicker reporting back to the requesting clinician

- Digital imaging allows for computer aided detection (CAD)
    - Using artificial intelligence, CAD identifies mammogram abnormalities
    - CAD appears to be about as accurate as the interpretation by a radiologist
    - One study confirmed that experienced radiologists used CAD after they reviewed the images and 50% of lesions missed without CAD were detected with CAD [11]
    - More detail about CAD is available at E-medicine [12]

Several studies have shown increased efficiency after converting to an enterprise PACS. In a study by Reiner, inpatient radiology utilization increased by 82% and outpatient utilization by 21% after transition to a film-less operation, due to greater efficiency. [13] In another study conducted at the University of California Davis Health System, transition to digital radiology resulted in: a decrease in the average image search time from 16 to 2 minutes (equivalent to more than $1 million savings annually in physician's time); a decrease in film printing by 73% and file clerk full time equivalents (FTEs) dropped by 50% (equivalent to more than $2 million savings annually).[14] The Health Alliance Plan implemented PACS at Henry Ford Health Systems in 2003. Results indicate: turnaround time for film retrieval dropped from 96 hours to 36 minutes; net savings of $15 per film and key players noted significant time savings.[15]

PACS disadvantages

- Cost, although innovations such as open source and "rental PACS" are alternatives [16-17]
- New legislation cutting reimbursement rates for certain radiology procedures [18]
- Integration with hospital and radiology information systems and EHR
- Bandwidth limits
- Workstation limits
- Different vendors may use different DICOMS tags to label films
- Viewing digital images a little slower than routine x-ray films
- Black and white computer monitors not as bright as traditional x-ray view boxes. This may be an issue with radiologists, but not the average physician [10]

Key Points

- PACS is the logical result of digitizing x-rays, developing better monitors and improving medical information networks and electronic health records
- PACS is well accepted by radiologists and referring physicians because of the ease of retrieval and the quality of the images
- PACS is a type of teleradiology, in that images can be viewed remotely by multiple clinicians on the same network
- Cost and integration are the only significant barriers to the widespread adoption of PACS

Conclusion

The status of PACS is similar to the issue with electronic health records; it is an expensive new technology that is slowly being implemented in the medical field. Unlike the EHR, there is much

less of a concern about acceptance, security, implementation and training. PACS is now held in high regard by radiologists, non-radiology physicians and healthcare organizations, but CEOs and CIOs worry about the initial price tag. The assumption made by many is that within several years there will be a significant return on investment. PACS is an inevitable technological evolution like wireless connectivity but financial obstacles will likely delay widespread implementation.

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18

Bioinformatics

ROBERT E HOYT

Learning Objectives

After reading this chapter the reader should be able to:

- Define Bioinformatics and how it interfaces with Medical Informatics
- State the importance of Bioinformatics in future medical treatment
- Describe the Human Genome project and its many important implications
- List private and governmental Bioinformatics databases
- Describe the application of Bioinformatics in genetic profiling of individuals and large populations

A commonly quoted definition of Bioinformatics is:

"the field of science in which biology, computer science and information technology merge to form a single discipline"[1]

In the past two decades the field of Bioinformatics has been involved with the creation of biological databases that helped evaluate DNA sequences and other genetic proteins. This allowed scientists to study the genetic information in the databases or add new information. The process of interpreting genetic data is referred to as **computational biology** that uses algorithms and artificial intelligence to:

- Find the genes of various organisms
- Predict the structure and/or function of newly developed proteins
- Develop protein models
- Examine evolutionary relationships[2-3]

There are other bioinformatics terms worth defining:

- **Genomics**: the field that analyzes genetic material from a species
- **Proteomics**: the study of gene expression at the level of proteins
- **Pharmacogenomics**: the study of genetic material to look for drug targets

How can Bioinformatics be useful today?

Besides diagnosing the 3000-4000 hereditary diseases that exist today, bioinformatics may be helpful in the following areas:

- Protein research to discover more targets for future drugs
- Pharmacogenomics to personalize drugs based on genetic profiles
- Complete genetic profiles will lead to better preventive medicine tests

- Gene therapy to treat diseases such as cancer. The most common way to achieve this is to use genetically altered viruses that carry human DNA. This approach, however, has not been proven to be helpful and not approved by the FDA
- Microbial genome alterations for energy production (bio-fuels), environmental cleanup, industrial processing and waste reduction
- Genetically engineered drought and disease resistant plants
- In spite of these interesting areas, it is estimated that less than 0.01% of microbes have been cultured and characterized. As an exception, the complete genome for the common human parasite Trichomonas vaginalis was reported in the January 2007 issue of the journal Science.[4] NIH will now embark on the Human Microbiome Project that will identify the genomes for 600 microbes that are related to health[5]

Bioinformatics Programs

The Human Genome Project (HGP)

One of the greatest accomplishments in medicine and the field of Biology is the Human Genome Project. This international collaborative project, sponsored by the US Department of Energy and the National Institutes of Health, was started in 1990 and finished in 2003. In the process of evaluating the human genome (complete set of DNA sequences for the 23 chromosomes), investigators compared the human DNA results with those of the fruit fly, the bacterium E.coli and the house mouse. By mid-2007 they had identified about 3 million differences in the sequences known as single-nucleotide polymorphisms (SNPs). In addition, the HGP addressed the ethical, legal and social issues associated with the project. Now that the HGP has been completed, it will take many years to analyze and learn from the databases.[6-8] Figure 18.1 displays the DNA sequencing of just chromosome number 12. Huge relational databases are necessary to store and retrieve this information. New technologies such as DNA arrays (gene chips) help speed the analysis and comparison of DNA fragments.[9]

Human Variome Project

This Australian initiative began in 2006 with the goal to create systems and standards for storage, transmission and use of genetic variations to improve health. Rather than catalogue “normal” genomes they focus on the abnormalities that cause disease. Another aspect of their vision is to provide free public access to their databases.[10]

National Center for Biotechnology Information

The NCBI was created in 1988 and is part of the National Library of Medicine and the National Institutes of Health. They host 10 different genetic databases and thereby are considered the world’s largest biomedical research center. The NCBI provides access to the complete genomes of over 1,000 organisms. Genomes represent both completely sequenced organisms and those for which sequencing is still in progress. NCBI databases are listed in figure 18.2.

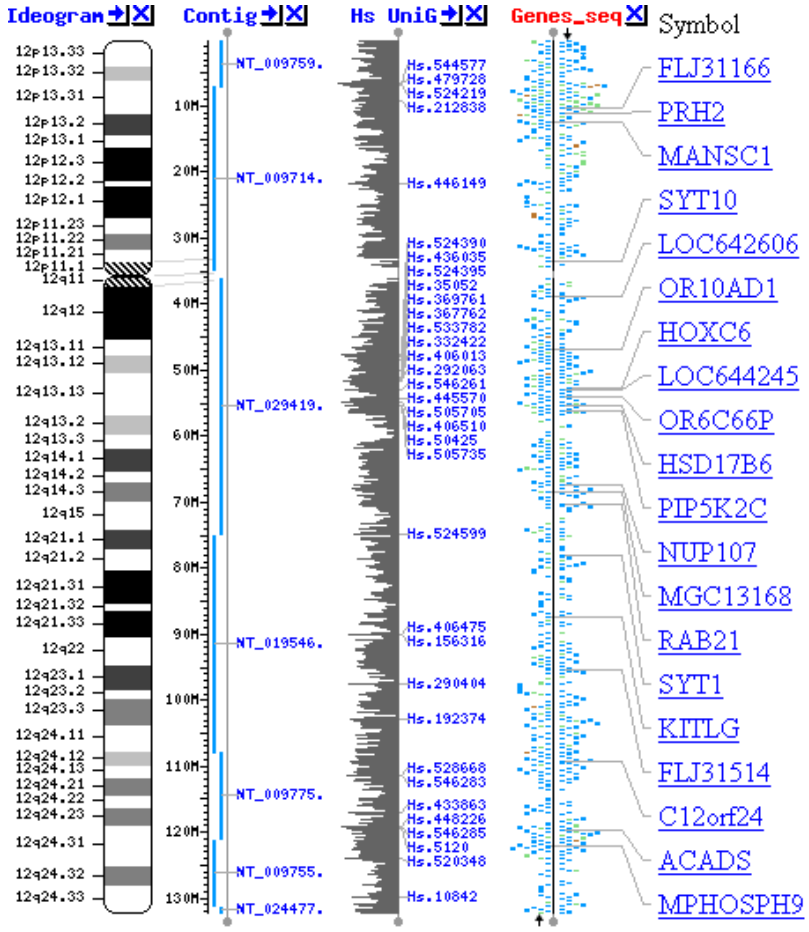

Figure 18.1 DNA sequences from chromosome 12 (Courtesy National Library of Medicine)

Nucleotide: sequence database (includes GenBank)
Protein: sequence database
Genome: whole genome sequences
Structure: three-dimensional macromolecular structures
Taxonomy: organisms in GenBank
SNP: single nucleotide polymorphism
Gene: gene-centered information
HomoloGene: eukaryotic homology groups
PubChem Compound: unique small molecule chemical structures
PubChem Substance: deposited chemical substance records
Genome Project: genome project information
UniGene: gene-oriented clusters of transcript sequences
CDD: conserved protein domain database
3D Domains: domains from Entrez Structure
UniSTS: markers and mapping data
PopSet: population study data sets
GEO Profiles: expression and molecular abundance profiles
GEO DataSets: experimental sets of GEO data
Cancer Chromosomes: cytogenetic databases
PubChem BioAssay: bioactivity screens of chemical substances
GENSAT: gene expression atlas of mouse central nervous system
Probe: sequence-specific reagents

Figure 18.2 NCBI Databases (Courtesy National Library of Medicine)

If you access the Genome project as listed above you can do a search for specific genes or proteins from different species. Figure 18.3 demonstrates the result of an Entrez Gene search for a tumor protein (TP53).

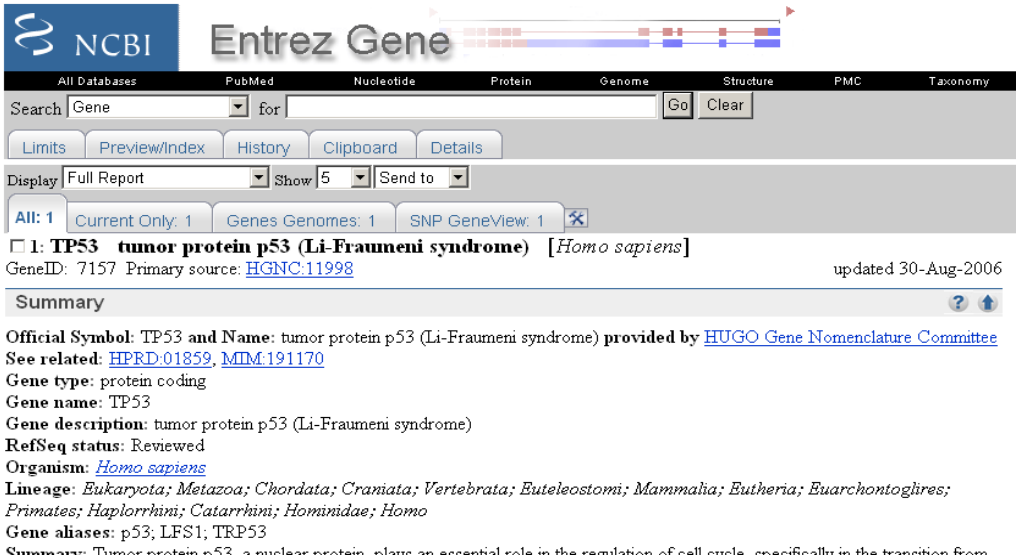
NCBI
Entrez Gene
All Databases PubMed Nucleotide Protein Genome Structure PMC Taxonomy
Search Gene for Go Clear
Limits Preview/Index History Clipboard Details
Display Full Report Show 5 Send to
All: 1 Current Only: 1 Genes Genomes: 1 SNP GeneView: 1
1: TP53 tumor protein p53 (Li-Fraumeni syndrome) [Homo sapiens]
GeneID: 7157 Primary source: HGNC:11998
updated 30-Aug-2006
Summary
Official Symbol: TP53 and Name: tumor protein p53 (Li-Fraumeni syndrome) provided by HUGO Gene Nomenclature Committee
See related: HPRD:01859, MIM:191170
Gene type: protein coding
Gene name: TP53
Gene description: tumor protein p53 (Li-Fraumeni syndrome)
RefSeq status: Reviewed
Organism: Homo sapiens
Lineage: Eukaryota; Metazoa; Chordata; Craniata; Vertebrata; Euteleostomi; Mammalia; Eutheria; Euarchontoglires; Primates; Haplorrhini; Catarrhini; Hominidae; Homo
Gene aliases: p53; LFS1; TRP53

Figure 18.3 Search for a specific protein (Courtesy National Library of Medicine)

The NCBI site also includes the search engine BLAST (basic local alignment search tool) that compares nucleotide or protein sequences to sequence databases and calculates the statistical significance of matches.[11]

National Genome Research Institute

This institute is part of the National Institute of Health (NIH) and helps organize current research, available grants, educational resources, careers and policies & ethics. They lead the Human Genome Project for the NIH.[12]

GenBank

This database was established in 1982 and is the NIH genetic sequence database that is a collection of all publicly available DNA sequences (100 gigabases), the largest in the world. Interestingly, many medical journals now require submission of sequences to a database prior to publication and this can be done with NCBI tools such as BankIt.[13]

Merck Gene Index

Private industry has recognized the tremendous potential of bioinformatics in research. In 1995 Merck Research Laboratory in collaboration with Washington University released to the public 15,000 gene sequences. Their ongoing releases will go to GenBank for international genetic researchers to develop future therapeutic agents.[14]

The Human Gene Mutation Database

The HGMD is a British site that attempts to collate human genetic mutations that cause inherited diseases. This has practical significance for clinicians, researchers and genetic counselors.[15]

The Online Mendelian Inheritance in Man

This is another NCBI database of genetic data and human genetic disorders. It is sponsored by Johns Hopkins University and Dr. Victor McKusick, a pioneer in genetic metabolic abnormalities. It includes an extensive reference section linked to PubMed that is continuously updated.[16]

World Community Grid

This project was launched by IBM in 2004 and simply asked people to donate idle computer time. By 2007 over 500,000 computers were involved in creating a super-computer used in Bioinformatics. Projects include Help defeat Cancer, Fight AIDS@Home, Genome Comparison and Human Proteome Folding projects. This grid will greatly expedite biomedical research by analyzing complex databases more rapidly as a result of this grid.[17-18]

Pharmacogenomics Knowledge Base

This organization created by Stanford University looks at the relationships between genetics, disease and drugs. There are sections on drugs, medical literature, variant genes, pathways, diseases and phenotypes that are searchable.[19]

Framingham Heart Study SHARe Genome-Wide Association Study.

In 2007, the Framingham Heart Study began a new phase by genotyping 17,000+ subjects as part of the FHS SHARe (SNP Health Association Resource) project. The SHARe database is located at NCBI's dbGaP and will contain all 550,000 SNPs and a vast array of phenotype information available in all three generations of FHS subjects. These will include measures of the major risk factors such as systolic blood pressure, total, LDL and HDL cholesterol, fasting glucose, and cigarette use, as well as anthropomorphic measures such as body mass index, biomarkers such as fibrinogen and C-reactive protein (CRP) and electrocardiography measures such as the QT interval.[20]

Cancer Biomedical Informatics Grid (CaBIG)

The Cancer Biomedical Informatics Grid is an IT project sponsored by the National Cancer Institute. The architecture is known as CaGrid and is an open-source service oriented architecture (SOA). The infrastructure will support the collection and analysis of data from disparate systems to promote biomedical research. The core software and associated tools can be downloaded from their web site.[21-22]

For more information on Bioinformatics and genetic databases, we refer you to the classic Biomedical Informatics textbook by Shortliffe and Cimino.[23]

What is the future direction of bioinformatics?

At least three trends are appearing with regards to bioinformatics: 1) integrating genomic information with electronic health records 2) personal genetic services 3) population-based genetic data.

Integration with electronic health records: The patient's genetic profile will be one more data field in the electronic health record. Recently, gene variants have been identified for diabetes, Crohn's disease, rheumatoid arthritis, bipolar disorder, coronary artery disease and multiple other diseases.[24] In late 2006 the Veterans Affairs healthcare system began collecting blood to generate genetic data that it will link to its EHR. The goal is to bank 100,000 specimens as a pilot project and link this information to new drug trials.[25] Similarly, Kaiser-Permanente has created the Research

Program on Genes, Environment and Health. In the first phase, 2 million members will be surveyed to determine their medical history, exercise and eating habits. The second phase (2008) will require the voluntary submission of genetic material.[26] SNOMED is making changes to its codes to include genetic information and the National eHealth Initiative is developing "use cases" for family history and genetics so standards can be created by organizations like the Health Information Technology Standards Panel. Organizations such as Partners Health, IBM, Cerner and multiple data mining vendors are all gearing up to add genetic information to what we currently know about patients and integrate that with electronic health records.[27]

The Agency for Healthcare Research and Quality (AHRQ) is developing computer-based clinical decision support tools to help clinicians use genetic information to treat breast cancer. The tools that could be integrated into EHRs are: whether women with a family history of breast cancer need BRCA1/BRCA2 testing and which women who already have breast cancer need genetic testing.[28]

It is surprising that family history is often overlooked by clinicians and that it does not always exist as computable data for analysis. To our knowledge, no electronic health record collects this information and uses it for clinical decision support. Data standards have been developed so family history can be part of EHRs and PHRs and be shared.[29] There is a new government sponsored free tool available for the public to upload their family history using the newest data standards. In this way, the results can be saved as a XML file and shared by EHRs and PHRs. *My Family Health Portrait* is available for English or Spanish speaking patients, is easy to use but does not store any patient information on the site. Instead, patients can store the XML file on their personal computers.[30] The program is open-source and downloadable from this site.[31]

Personal Genetics: Patients will want to know their own genetic profile even if the consequences are uncertain. Companies such as *Celera Genomics* will take advantage of the genomics project to offer genetic mapping services and pharmacogenomics.[32] *DNA Direct* is another company that offers online genetic testing and counseling. They do offer both patient and physician education and have staff genetic counselors.[33]

Decode Genetics Corporation will collect disease, genetic and genealogical data for the entire population of Iceland. Their goal is to develop better drugs based on genetic profiles. They currently have three profiles: Complete analysis for 39 diseases, traits and ancestry for $1000, Cardio Scan for 6 cardiovascular diseases for $195 and Cancer Scan for 7 common cancers for $225. A simple mouth wash provides the DNA needed for analysis.[34] *23andMe* is a direct-to-consumer online genetic testing company. For $399 they will send a testing kit to homes based on analyzing saliva with a turnaround time of 4-6 weeks. Cu**rrently, they look** for 30 diseases or conditions they feel are strongly genetically linked and 86 diseases or conditions where the evidence is much weaker. They also offer an analysis of ancestry based on the genetic profile.[35] Google's co-founder Sergey Brin has funded a project through this company to study the genetic inheritance of Parkinson's disease. They hope to recruit 10,000 subjects from various organizations and offer a discount price for complete analysis.[36]

Multiple labs such as Affymetrix and Pacific Biosciences have the technology to genotype with microarrays with the goal of producing a faster and less expensive genetic analysis.[27]

Population Studies: *Oracle Corporation* will partner with the government of Thailand to develop a database to store medical and genetic records. This initiative was undertaken to offer individualized "tailor made" medications and to offer bio-surveillance for future outbreaks of infectious diseases such as avian influenza.[37] Harvard University has developed a new program "Informatics for Integrating Biology at the Bedside" to analyze 2.5 million patient records to look for links between DNA and illnesses such as asthma. It is known that certain patients respond poorly to standard

asthma medications and the root may be genetic. Artificial intelligence will be used to search medical records for terms such as asthma and smoking.[38]

Genetic Prediction Obstacles

In order for genetics to enter the mainstream, new technologies and specialties will need to be developed and numerous ethical questions will arise. Just finding the abnormal gene is the starting point. Genetic tests will have to be highly sensitive and specific to be accepted. In general, patients will not be willing to undergo a prophylactic mastectomy or prostatectomy to prevent cancer unless the genetic testing is nearly perfect. Additionally, the Genetic Information Nondiscrimination Act of 2008 was passed to protect patients against discrimination by employers and insurers based on genetic information.[39]

Many obstacles face the routine ordering of genetic tests by the average patient. Ioannidis et al points out that in order for genetic testing to be reasonable the following must be true:

- The disease you are interested in is common. Even with common breast cancer, when you evaluate 7 established genetic variants, they only explain about 5% of the risk for the cancer. If the disease (example Crohn's disease) is rare, then the test must be highly predictive
- In order for genetic testing to be relevant you should have an effective treatment to offer, otherwise there is little benefit
- The test must be cost effective, as many currently are too expensive. As an example, screening for sensitivity to the blood thinner warfarin (Coumadin) makes little sense at this time due to cost [40]

Two recent articles drive home these points:

- When the risk of cardiovascular disease based on the chromosome 9p21.3 abnormality was evaluated in white women, it only slightly improved on the ability to predict cardiovascular disease above standard, well-accepted risk factors[41]
- Meigs et al looked at whether multiple genetic abnormalities associated with Type 2 diabetes would be predictive of the disease. They found that the score based on 18 genetic abnormalities only slightly improved the ability to predict diabetes, compared to commonly accepted risk factors[42]

Key Points

- Bioinformatics will introduce a treasure trove of genetic information into the field of medicine
- At this point Bioinformatics seems like a field remote from medicine, but that will change with pharmacogenomics and personal genetic profiles
- Many organizations worldwide are beginning to collect and collate genetic information
- Electronic health records will incorporate genetic profiles in the future

Conclusion

At this point the Human Genome Project and Bioinformatics will seem foreign to most clinicians. When they can access data that tells them who should be screened for certain cancers and which drugs are effective in which patients, these developments will be part of their day to day practices. In the meantime, scientists and biomedical companies will continue to add to the many genetic databases, develop genetic screening tools and get ready for one of the newest revolutions in medicine. The American Health Information Community (AHIC) recommended in 2008 that the federal government should prepare for the storage and integration of genetic information into many facets of healthcare.[43] Their recommendations will initiate the necessary dialogue that must take place to prepare for bioinformatics to align with the practice of medicine.

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19

Public Health Informatics

ROBERT E HOYT

Learning Objectives

After reading this chapter the reader should be able to:

- Define the scope and goals of public health informatics
- State the significance of the Public Health Information Network
- Identify the various disparate public health informatics programs
- Describe the current biosurveillance programs
- State the significance of syndromic surveillance for early detection of bioterrorism and natural epidemics

The field of public health studies populations and not individuals. Public health tracks trends in the health of populations with the goal of preventing disease or detecting it early enough to initiate treatment. In order to study a large population you need information technology such as networks, databases and reporting software. The following is a frequently cited 1995 definition of Public Health Informatics:

> *"the systematic application of information and computer science and technology to public health practice, research and learning"*[1]

Prior to 2001, Public Health reporting consisted of hospitals and clinics sending paper reports to local health departments, who in turn forwarded information to state health departments, who sent the final data to the Centers for Disease Control (CDC) via mail or fax. This system would not suffice for epidemics or bioterrorism. The events of September 11, 2001 only heightened the concern for the means to detect illnesses and perform bio-surveillance more rapidly and accurately. Paper-based reporting is simply inadequate to detect subtleties in symptoms and inadequate to report large volumes of data to a central data repository. With an electronic system, artificial intelligence and rules engines could detect trends and alert officials. If the United States had a mature national health information network linked to EHRs in every medical facility, the reporting of data would be uniform, rapid and easy to analyze. In 2006 the United Kingdom began using *QFlu,* a national influenza surveillance system. The system collects data on the diagnosis and treatment of flu-like illnesses on a daily basis from over 3,000 physicians. Thanks to an almost universal health record, electronic reporting in the UK has been greatly facilitated.[2] The United States, on the other hand, has spent billions of dollars on biosurveillance and has little to show for it, largely because of disparate systems and the lack of a nationwide health information network.[3]

Public Health Information Network (PHIN)

The creation of a Public Health Informatics Network (PHIN) faces many of the same issues shared by the Nationwide Health Informatics Network (NHIN). Both require data standards, databases, networks, tight security and decision support. The sources of public health data are also very disparate, deriving from hospitals, clinics, public health offices, labs, environmental agencies and

poison control centers.[4] Similarly, they both face budgetary hurdles due to their complexity, difficulty in implementation and need for a long term business plan.

The PHIN is a relatively new CDC concept with its roots starting in 2004. The goal is to link together the players involved with US Public Health, using well established data standards. The vision is to improve disease surveillance, health status indicators, data analysis, monitoring, intervention, prevention, decision support, knowledge management, alerting and the official public health response. They envision interoperability with EHRs as part of "meaningful use".

In reality the PHIN is a set of programs and not a distinct network.[5-6] Its first program was the PHIN Preparedness Initiative. This initiative was funded for $849 million dollars in 2004 to improve preparedness in all states and US territories. It is estimated that about 25% will go towards information technology. At this point the initiative will:

- Define the functional requirements including early event detection, outbreak management and connection of lab systems
- Identify and use industry wide data standards like HL7 and LOINC
- Make software solutions available for public health partners[7]

National Center for Public Health Informatics (NCPHI) is one of 11 Centers within the Centers for Disease Control and Prevention in Atlanta, Georgia. Established in 2005, it has the goal to provide national leadership to transform public health through informatics. The Center consists of 5 divisions to lead in areas of emergency preparedness and response, integrated surveillance systems, informatics, alliance management and consultation and knowledge management services. Several of the programs we will discuss in this section fall under the Center's divisions. They also support 5 Centers of Public Health Excellence at the University of Washington, University of Utah, Johns Hopkins University, New York City Health Department and Harvard Medical School.[8] NCPHI supports the National Notifiable Diseases Surveillance Program (NNDS) which consists of the following programs:

- **The National Electronic Disease Surveillance System (NEDSS)** is a major component of the PHIN that will create an interoperable surveillance system between federal, state and local networks. Specifically it will connect public health, laboratories and clinicians to support disease surveillance. The system will replace several older systems and gather as well as analyze data.[9]
- **The National Notifiable Diseases Surveilllance System (NNDSS)** is a state based surveillance system for conditions deemed to be nationally notifiable.

The CDC has also created an Outbreak Management System (OMS) program that is web based and might be used in the field on a lap top computer during an actual outbreak.[10] Additional grants of $15 million will come from the Robert Wood Johnson Foundation and the program office will be the Public Health Informatics Institute.[11] The CDC has also created the Health Alert Network (HAN) that will function as PHIN's health alert component. The intent is to disseminate alerts and advisories via the Internet at the state and local levels. By late 2006 all 50 states were connected to the HAN and are funded for continuation of the initiative.[12]

Epi-X is a highly secure communications network that ties together select Public Health officials (about 4,200 users) around the United States. The system allows for rapid reporting, alerts and discussions about possible disease outbreaks. Since its inception in 2000 over 1000 disease reports have been posted to include sentinel events such as the 2002 West Nile virus outbreak.[13]

Epi Info is a public domain software suite developed by the CDC for public health officials and researchers that creates a database that can be analyzed along with graphs and maps. Users can develop a questionnaire for epidemiology studies and visualize an outbreak by using "geographic

information systems" (GIS). Features also include: compatibility with Microsoft Access, SQL and ODBC databases, a report tool, EpiMap, a nutrition/anthropometry program and statistical tools. Version 3.5 was released in June 2008 as a free downloadable program from the web site or available on CD-ROM.[14]

TransStat is a software program developed by the National Institute of Health that is available as a free download for public health officials. Data such as age, sex, time of onset of symptoms, contacts, etc will be entered if there is a people-to-people or animal-to-animal epidemic. The software helps to determine if an individual contacted the illness from another individual, the rate an infection could spread and other epidemiologic information. The program was developed as part of the NIH Models of Infectious Disease Agent Study (MIDAS).[15]

Biosurveillance Programs

Biosurveillance. The CDC is not the only federal agency engaged with biosurveillance activities. The Department of Homeland Security (DHS) established the National Biosurveillance Integration System that will combine data from the CDC, US Department of Agriculture and environmental monitoring from the program BioWatch to improve pandemic and bioterrorism detection and response.[16] BioWatch is a Homeland Security Department program that monitors bioterrorism sensors in major US cities. The sensors are located with EPA air quality sensors[17]

Syndromic surveillance. An important new Public Health function is syndromic surveillance defined as "*surveillance using health-related data that precede diagnosis and signal a sufficient probability of a case or an outbreak to warrant further public health response"*[18]It means that symptoms are monitored (like diarrhea or cough) before an actual diagnosis is made. If, for example, multiple individuals complain of stomach symptoms over a short period of time, you can assume there is an outbreak of gastroenteritis. In addition to the obvious sources of health data, public health officials can also monitor and analyze:

- Unexplained deaths
- Insurance claims
- School absenteeism
- Work absenteeism
- Over the counter medication sales
- Internet based health inquiries by the public
- Animal illnesses or deaths [19]

Initially, public health officials were very interested in detecting trends or epidemics in infectious diseases such as severe acute respiratory syndrome (SARS) and avian influenza. After the terrorist attacks and anthrax outbreak in 2001, they have had to improve biosurveillance to detect bioterrorism. The objective is to "*identify illness clusters early, before diagnoses are confirmed and reported to public health agencies and to mobilize a rapid response, thereby reducing morbidity and mortality*" [20] The challenge is to develop elaborate systems that can sort through the information and reduce the signal to noise ratio. The syndrome categories that are most commonly monitored are:

- Botulism-like illnesses
- Febrile (fever) illnesses (influenza-like illnesses)
- Gastrointestinal (stomach) symptoms
- Hemorrhagic (bleeding) illnesses
- Neurological syndromes

- Rash associated illnesses
- Respiratory syndromes
- Shock or coma

Ambulatory electronic health records (EHRs) are a potentially rich source of data that can be used to track disease trends and biosurveillance. EHRs contain both structured (ICD-9 coded) data as well as narrative free text. Hripcsak et al assessed the value of outpatient EHR data for syndromic surveillance. Specifically, they developed systems to identify influenza-like illnesses and gastrointestinal infectious illnesses from Epic® EHR data from 13 community health centers. The first system analyzed structured EHR data and the second used natural language processing (MedLEE processor) of narrative data. The two systems were compared to influenza lab isolates and to a verified emergency room (ER) department surveillance system based on "chief complaint". The results showed that for influenza-like illnesses the structured and narrative data correlated well with proven cases of influenza and ER data. For gastrointestinal infectious diseases, the structured data correlated very well but the narrative data correlated less well. They concluded that EHR structured data was a reasonable source of biosurveillance data. [21]

The Electronic Surveillance System for the Early Notification of Community Based Epidemics (ESSENCE) is part of the Department of Defense Global Emerging Infections System (DOD-GEIS). It began in the national capital area in 1999 and by 2001 it was in place at military treatment facilities (MTFs). The national capital area was selected due to its increased risk of bioterrorism. Over the past three years data has been collected from 121 Army, 110 Navy and 80 Air Force installations worldwide. ESSENCE receives and analyzes data for about 90,000 outpatient and emergency room visits daily for the Department of Defense facilities. The syndromic surveillance data comes from outpatient encounters (standardized ambulatory data record) that include patient demographics and ICD-9 diagnostic codes. The data is sent to a centralized server in Denver, Colorado. Every 8 hours data related to the syndromes described above is downloaded and graphed to compare daily trends with historical data. Unfortunately, it still takes several days for the data to arrive at the central server. In spite of this delay, there have been several instances where the surveillance network has identified early outbreaks before local authorities were aware. Newer versions have evolved due to collaborative efforts with Johns Hopkins University Applied Physics Laboratory and the Division of Preventive Medicine at the Walter Reed Army Institute of Research. ESSENCE II incorporated civilian data. ESSENCE IV is the most current version with the following features:

- Chemical-Biological detectors in limited distribution
- Data from civilian emergency rooms
- Prescription data
- Data from the Veterans system
- National insurance claims data
- Over the counter drug sales
- Standard reportable diseases such as TB, meningitis, etc [22]

BioSense. This is a CDC national web based program to improve disease detection, monitoring and situational awareness for healthcare organizations in the United States by reporting emergency room data. The program will address identification, tracking and management of naturally occurring events as well as bioterrorism. Through the BioIntelligence Center, the CDC will assist in the analysis of almost real-time data using advanced algorithms, statisticians and epidemiologists. This program will be part of the PHIN and use data standards such as HL7, SNOMED and LOINC. They currently have about 800 users from 570 non-governmental hospitals (10%) and 1300

Department of Defense and VA hospitals (100%). In 2008 the program looked at the utility of connecting HIOs and testing the program during the seasonal influenza epidemic. [23]

GOARN. The Global Outbreak Alert and Response Network was established in 1997 and is supported by the World Health Organization (WHO). The severe acute respiratory syndrome (SARS) outbreak in 2003 was the first opportunity for the GOARN to be utilized. Since 2000 they have responded to more than 50 events worldwide. Features of the system include:

- Network provides an operational framework to alert the international community about outbreaks
- A technical collaboration to pool human resources for rapid identification, confirmation and response to outbreaks [24]

FluNet is another WHO initiative that is part of the WHO Communicable Disease Global Atlas. The goal is to collect and analyze infectious disease data from a country and global perspective. The Atlas will collect demographic and epidemiologic data so it can be used for queries, disease mapping and access to resources.[25]

Google Flu Trends is a web-based program launched by the philanthropic section of Google. This program analyzes web searches on influenza-related topics to estimate influenza frequency and maps of different regions of the US. Their results correlated strongly with data from the CDC and it is felt that Google trends might precede CDC results by about one week. Currently, they are studying trends from the US, Australia, New Zealand and Mexico. For the United States you can also look at trends by state.[26 -28] Figure 19.1 shows trends in the 2008-2009 flu season, while figure 19.2 shows yearly peaks using Google versus CDC data.

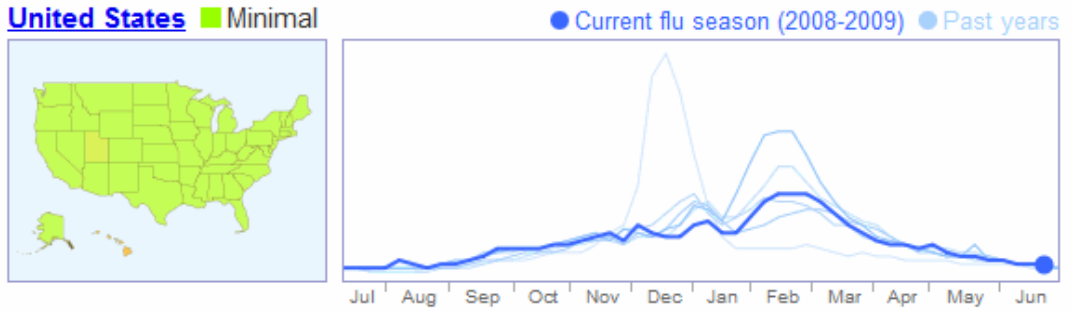

Figure 19.1 2008-2009 US Flu Trends (Courtesy Google Flu Trends)

Figure 19.2 Annual Flu spikes; CDC data versus Google (Courtesy Google Flu Trends)

eLEXNET (electronic laboratory exchange network) is a web based information network that provides real time access to food safety analysis. The site has tools to look for trends, geographical locations, etc. Network allows food safety experts to collaborate. [29]

Global Public Health Intelligence Network is an earlier Canadian initiative that monitors news media on the Internet in seven languages from around the world and reports on emerging disease threats. Of interest is the fact that the GPHIN detected the 2002-2003 SARS outbreaks with this technology. The information is automatically collated and analyzed by public health officials. There is a cost to subscribe to the service.[30]

Open-Source Utah Disease Tracking System is the first open-source web-based infectious disease tracking and management system in the US. The software (TriSano) is part of the Collaborative Software Initiative. It will track and manage infectious diseases, biohazards and bioterrorism. The program can be downloaded from the TriSano web site for public use and customization. [31-32]

Geographic Information Systems (GISs)

As early as 1855 Dr. John Snow created a simple map to show where patients with cholera lived in London. As a result of his mapping he determined the epidemic was caused by a common water pump. We have come a long way since then thanks to the Internet and other technologies. Modern GIS uses digitized maps from satellites or aerial photography. Variables can be inputted by zip code, latitude, longitude, etc. There are two modes to overlay data into a GIS: *Raster* or into a grid or *Vector* into points, lines or polycons. Using GPS and mobile technology, field workers can enter epidemiologic data that can populate a GIS. This geospatial visualization is helpful to track infection diseases, natural disasters and bioterrorism. Many more details are available on these web sites.[33-35]

HealthMap is a global project to integrate infectious disease news and visualization using an Internet geographic map. This program classifies alerts by location and disease. For example you can select "Salmonella" and the "United States" and see if there were any reported cases in the past 30 days (figure 19.3).[36] Mouse over an icon and you will see what is being reported in that area. The program was developed by the Harvard-MIT Division of Health Sciences and Technology and a more detailed explanation of the system and architecture is provided at this reference.[37]

Zyxware Health Monitoring System uses Google Maps as the GIS platform to track communicable diseases. This is an open-source software program written in PHP/MySQL and available for download from sourceforge.net [38]

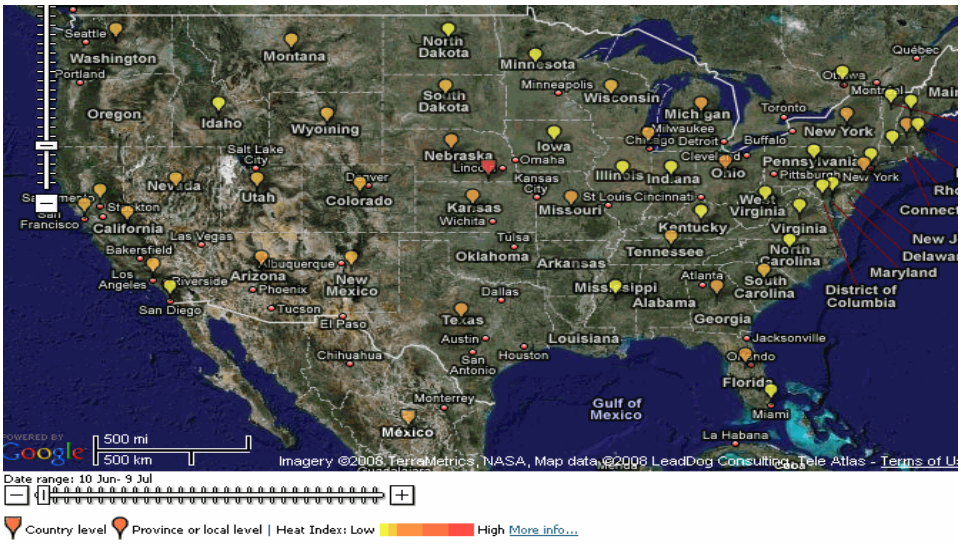

Figure 19.3 HealthMap search results for Salmonella (Courtesy HealthMap)

Key Points

- Public health is concerned with the health of populations, instead of individuals
- In order to study large populations and track trends in health and bioterrorism, new high speed networks must exist. Paper-based reporting is no longer tenable
- Creating a Public Health Information Network (PHIN) will not be easy due to multiple disparate systems nationwide
- The creation of the PHIN will face the same issues as the NHIN: high cost and issues of privacy, security and interoperability

Conclusion

The potential of a Public Health Information Network is great but may not be achievable in the immediate future due to high cost and disparate systems.

Although the PHIN is critical for biosurveillance data reporting, it would also be important for reporting routine public health information such as influenza outbreaks and immunization status. In early 2008 the CDC awarded contracts worth $38 million to three health information exchange recipients to develop data sharing plans for public health information. [39] In September 2009 three states were able to report H1N1 data from emergency rooms to the CDC by using CONNECT and the NHIN. [40]

Geographic information systems, free or commercial, are now commonplace to correlate public health epidemiology data with geography to produce dramatic visual representation of a variety of conditions.

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20

E-Research

ROBERT E HOYT

Learning Objectives

After reading this chapter the reader should be able to:

- Identify the multiple ways information technology can improve research
- State the general benefits of research automation
- Describe the benefits of electronic collaborative web sites
- Describe the specific benefits of electronic case research forms
- Compare and contrast the pros and cons of PDA based research forms

One of the definitions of medical informatics cited in chapter one includes medical research:

> *"Medical informatics is the application of computers, communications and information technology and systems to all fields of medicine - medical care, medical education and medical research"*[1]

Like most areas in medicine, automation and digitization are making inroads, and research is no exception. At this point there is very little written about e-research in the medical literature, yet numerous commercial and home grown solutions now exist.[2] Ironically, there have been multiple advances in technology that could potentially make research automated, seamless and paperless.

Potential of information technology to improve research:

- Enhanced information retrieval through search engines such as Google and PubMed
- Automation of patient information
    - Online registration
    - Online surveys
    - Online recruitment of subjects
    - EHR recruitment of subjects[3]
- Electronic grant submission
- Data analysis with software programs such as Statistical Package for the Social Sciences (SPSS)[4] and Matlab[5]
- Software programs like LabVIEW can control medical devices, collate all data into a Microsoft Access database and display data real-time on a monitor during a study[6]
- E-collaboration web sites
- E-forms
- Service oriented architecture (SOA) can connect universities, pharmaceutical companies and other partners with major disparate databases and services worldwide

Paperless Research

Multiple problems exist with paper forms in regards to data collection, validation, entry and storage:

- Data collection and transcription errors may be unrecognized until after the study has been completed
- Paper forms require time to: create the forms, manually enter data and finally store data. More time required means more money spent
- Data storage takes up valuable space that could be used for more profitable ventures
- Data stored in filing cabinets limits collaboration within and outside an organization
- Data retrieval and analysis is slower with paper forms

The British market analyst Datamonitor estimated that large life science companies could save approximately $10-$12 million dollars annually by transitioning to electronic data capture and clinical trials management systems.[7] Several reports in the literature have suggested greater efficiency and cost savings by converting from paper to electronic case report forms (e-CRF).[8-10] Electronic forms are also effective for data validation and creating an audit trail. With the widespread approval of electronic signatures, there is little reason to rely on paper.

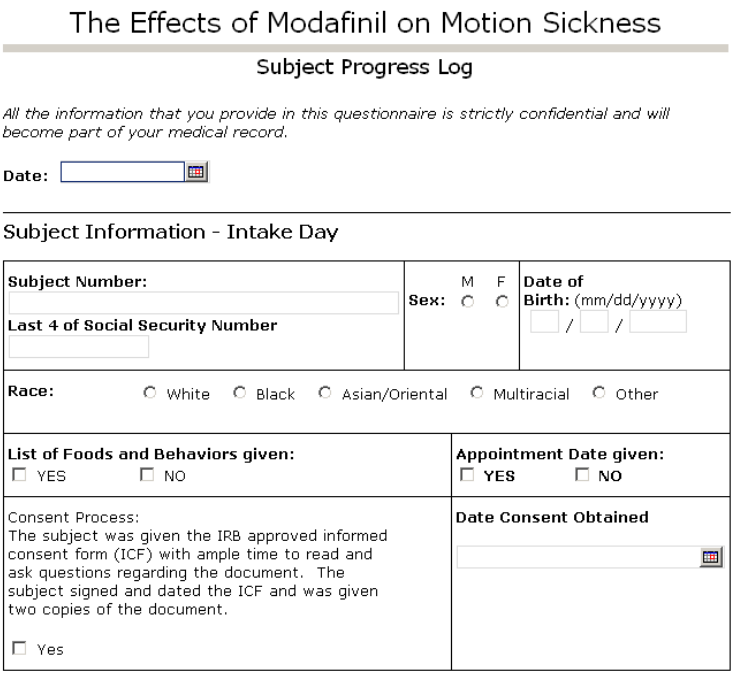
Forms of every description can be stored on a web site with data fields mapped to a back-end database. With data validation tools, this should result in fewer data entry and transcription errors. An alert would notify the person filling out the form that correction or completion of information is needed before the form can be submitted. Web based forms would require Internet access by the researcher using a PC or laptop computer in a wired or wireless mode. Additionally, patients can be recruited via e-mail and referred to forms on the web site. Some complicated web forms may require programming time to add necessary features. Excellent back up is mandatory.

Commercial-Off-the-Shelf (COTS) Forms for Research

An example of a comprehensive e-form generating program would be OneForm Designer Plus. Customizable html forms can be created for web pages with JavaScript coding or a PDF "fillable" form. Forms can then be hosted on a web site and data automatically sent to a database.[11]

Microsoft InfoPath is an e-forms generating software program that is part of the Microsoft Office Suite 2003 and 2007. The electronic form is usually created on a personal or laptop computer and then uploaded to a web site. InfoPath forms can be hosted on a web site, sent via e-mail or used on mobile devices. All data is written in XML (extensible markup language). Office SharePoint Server 2007 is a portal where InfoPath forms can be uploaded and managed. In that way users do not need to have InfoPath on their personal computers to complete a form. Forms creation is easy (drag-and-drop) and includes many shortcuts such as drop down menus. Forms can be created by converting Microsoft Word or Excel files. Incorrect and missing data can be detected with data validation tools. Figure 20.1 provides an example of a study form used for a drug trial.[12]

IBM purchased PureEdge forms in 2005 and they are now known as Lotus 3.0 forms. This comprehensive form generating program is available to use offline or hosted on a web page. The program uses XForms, the latest XML format and offers a mobile solution as well. The US Army now has more than 2000 forms available using this technology.[13]


The Effects of Modafinil on Motion Sickness

Subject Progress Log

All the information that you provide in this questionnaire is strictly confidential and will become part of your medical record.

Date:

Subject Information - Intake Day

Subject Number: **Last 4 of Social Security Number**	**Sex:** M F	**Date of Birth:** (mm/dd/yyyy) / /
Race: White Black Asian/Oriental Multiracial Other		
List of Foods and Behaviors given: YES NO		**Appointment Date given:** YES NO
Consent Process: The subject was given the IRB approved informed consent form (ICF) with ample time to read and ask questions regarding the document. The subject signed and dated the ICF and was given two copies of the document. Yes		**Date Consent Obtained**

Figure 20.1 InfoPath e-form

Mobile e-forms. Handheld computers have been used for more than a decade in clinical trials.[14] Studies have suggested that this technology is accurate and fast.[15-16] The main advantages they offer in research are their mobile nature, low cost and small form factor. Data can be collected anywhere, including in the field and later synchronized to a computer and uploaded to a database. The disadvantages are a small screen and relatively short battery life. PDA forms can be created by a programmer at considerable expense, but recently, commercial products exist that allow the average user to create forms. One of the products is Pendragon Forms that can build a form using 23 common field types that includes images and signatures. Form creation does not require any programming experience and a two week free download trial is available. The collected data uploads to an Access database on the computer, although an enterprise edition can synchronize data to a remote server.[17]

Electronic Case Report Forms (eCRFs)

Multiple vendors can produce electronic forms used in research to record patient data and events. Frequently, electronic forms reside on the local computer and are stored on a server, the client-server model. Because other aspects of research can now be electronic, automated and integrated, it has become more common to see electronic case report forms integrated with the other functions as a whole package. Researchers have created programs just for single trials using the client server model.The reality is that web-based programs offer more functionality and interoperability for multiple researchers located at multiple different sites. In the next section we will discuss additional comprehensive solutions that include more functions than just eCRFs.

The Need to Collaborate and Integrate

Whether it is within or between organizations, communication is very important. Traditionally, people meet face to face to discuss how they might partner to write a grant or paper or analyze data sets. This is relatively simple if the collaborators work in the same building or organization but difficult if they work in different states. What is needed therefore is a means to communicate

asynchronously and securely. The Internet provides the network and space to allow collaboration. Harris et al listed the key desirable features to promote effective biomedical e-research: 1) data access among different institutions 2) user authentication and role-based security 3) eCRFs 4) data validation and data quality checks 5) audit trails 6) protocol management 7) central data storage and backup 8) data export to statistical packages 9) data import capability from different sources.[18]

An appropriate web site for research can be home grown as described by Marshall and Haley in a 2000 article in the Journal of the American Medical Association. They enumerated the 10 major steps to create a secure collaborative web site and estimated its cost to be $20-$35,000 with annual maintenance costs of $2500. The article also pointed out that data in a digital format allows for more rapid uploading and analysis.[19] Avidan reported the use of a web based platform serving 37 medical centers in 17 European countries for a study of decision making in intensive care units. The article discussed the importance of data validation or the means to alert researchers when data is missing or incorrect. They point out four ways data can be validated to include client-sided or server-sided validation or both. The importance of local and remote validation is stressed to prevent missing data. Their solution used both commercial off the shelf (COTS) products and Java Script programming.[20] Other authors have also published their home grown web-based solutions.[21-23]

Commercial collaborative solutions have appeared on the horizon. As an example, *Simplified Clinical Data Systems* hosts a web-based solution that includes more than eCRFs. Some of the features of this research platform are as follows:

- Web site serves as a repository for all data collection tools, data storage and all documents related to the study
- Remote data entry via the Internet
- Online subject randomization
- Electronic case report forms (eCRFs) that are fee-based
- Data validation and audit trail
- Electronic signatures
- Automated real-time (e-mail) notifications for enrollment, adverse events, protocol deviations, subject visits, etc
- Integration with a wide variety of databases: Oracle, SQL Server, MS Access, etc
- Customized reports
- 128 bit SSL encryption for all system transactions
- Collaborators must log on with 3 types of information to include a 6 digit number contained on a key fob that changes every minute [24]

ClickCommerce is another commercial comprehensive administrative research software program. It includes additional tools for Institutional Review Board (IRB) requirements, grants and contracts management, e-forms library and several other research functions.[25]

Velos eResearch is a clinical research information system that supports account management, protocol management, patient management, IRB review and monitoring, project planning, study design, data safety monitoring and adverse event reporting. This web-based program integrates all of the research clinical data management functions with the administrative management. They are HL7 compliant and have interfaces for labs, devices and EHRs.[26]

OpenClinica is an open-source software application for research offered as a free download. Because it is web-based and not client-server based it provides a collaborative platform for researchers from different institutions. Its features include: protocol configuration, design of case report forms (CRFs), electronic data capture (EDC), retrieval and clinical data management. The application allows for importing and exporting of data sets to SPSS, CDISC, ODM and XML. It is

capable of supporting regulatory guidelines and is built upon a modern architecture based on common standards. In 2009 they have 5000 community members from 76 countries.[27] Figure 20.3 demonstrates OpenClinica with color coding of records.

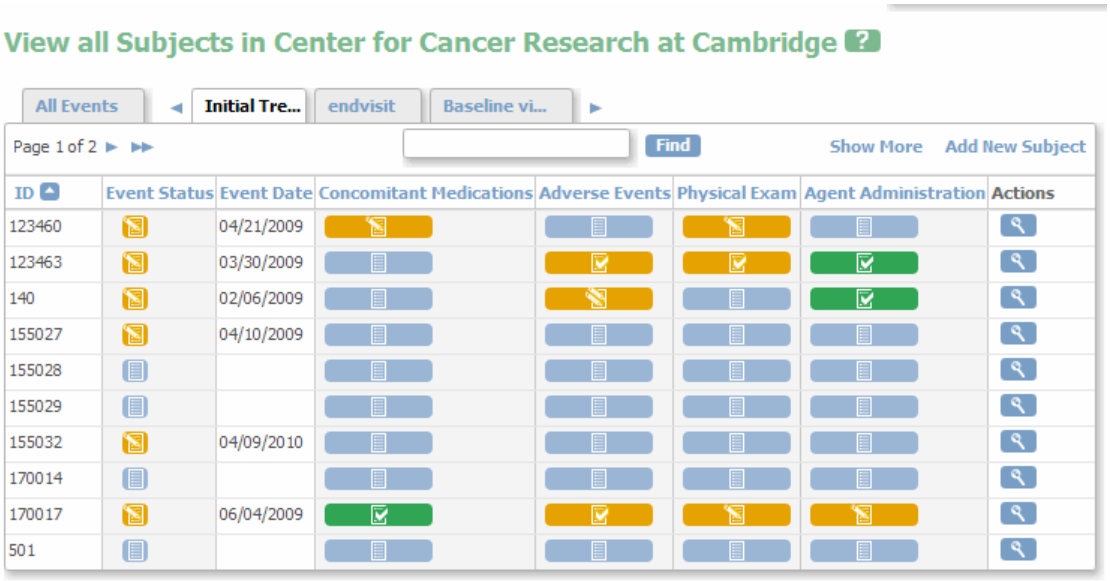


Figure 20.3 Sample research with OpenClinica (Courtesy OpenClinica)

REDCap (research electronic data capture) is another free web-based research platform. It actually consists of two web-based programs REDCap and REDCap Survey. It facilitates secure data capture, data validation, an audit trail and the ability to download seamlessly to statistical programs such as SPSS, SAS and Stata. It is currently available in English, Spanish and Japanese. The project is based on PHP and JavaScript programming with a MySQL database for data storage and management. The REDCap Survey tool is an online survey generating application used in research. Fifty-three organizations use this platform and to date it has been used for 650 studies. While this program is free to institutions, it is not open-source so the code cannot be customized and an "end-user license agreement" must be signed.[18, 28]

A 2004 article in The Journal of Urology by Lallas outlined how a commercial web-based product improved efficiency and collaboration among twenty-one participating institutions. He concluded that the program became more cost effective as the number of enrolled subjects increased. For instance, once eCRFs are created it doesn't cost any more to use them for more subjects. 83% of participants rated the new way to collaborate as satisfactory to excellent.[29]

Commercial off the Shelf Collaborative Tools

There are COTS tools that are available that facilitate collaboration that were not designed specifically for research. One example would be Microsoft's Sharepoint that is part of Microsoft's 2003 or 2007 Server. It creates a "do-it-yourself" web site with multiple tools and integration with Microsoft Office systems. The program requires minimal knowledge of technology and no programming skills. A disadvantage of this program platform is that, due to security reasons, many organizations may not allow remote access to their server. For that reason, additional solutions will be presented.[30]

Community Zero is a web-based online community platform that could also be used for collaborative research. The program has many of the same features of Microsoft SharePoint (discussions, document uploads, group e-mails, calendars, etc.). It also requires minimal experience to establish an online community. The cost is $49.95 per year and a 30 day free trial is available.[31]

OfficeZilla (related to Mozilla) is a free open source web based collaborative site with many of the same features as described previously.[32]

Service Oriented Architecture for Research

For large civilian and federal research organizations there is a growing trend to use web services and service oriented architecture (SOA) (see chapter 4 for further details) to connect disparate data and organizations. Perhaps the best example of this is the National Institutes of Health, a huge research organization that consists of 27 Institutes and Centers. In a statement by its Director, he noted that the new vision was to "*explore a standard clinical research informatics strategy, which will permit the formation of Nation-wide communities of clinical researchers made up of academic researchers, qualified community physicians and patient groups".*[33]

In order to execute the vision, the National Cancer Institute (NCI) created the cancer Biomedical Informatics Grid (CaBIG), also discussed in the chapter on Bioinformatics. This initiative was part of the National Cancer Institute Center for Biomedical Informatics and Technology (CBIT). The concept was to create a platform for all aspects of cancer research and for all participants, researchers, clinicians and patients. As of 2008, 46 NCI-designated Cancer Centers and 16 Community Cancer Centers have connected to the infrastructure and its set of tools. The architecture is known as CaGrid 1.3 and is an open access, open-source federated environment. More than 1000 software developers from 200 organizations contributed. Although intended for cancer research, this platform could be used for non-cancer research and they are poised to connect to EHRs and genomic databases. A list of CaBIG tools is available on their web site.[34]

Although smaller than CaBIG, other organizations have also created a network using SOA to facilitate collaboration and data exchange in genomics[35] and orthopedics.[36]

Clinical Research Informatics: An Emerging Sub-Domain

Another convergence has arisen between biomedical informatics and research, primarily due to the multiple new technologies listed above. This emerging new sub-domain of Biomedical Informatics would be known as Clinical Research Informatics. A proposed definition is a subdomain "*concerned with the development, application and evaluation of theories, methods and systems to optimize the design and conduct of clinical research and the analysis, interpretation and dissemination of the information generated".* This is in keeping with the NIH Road map to re-engineer how bench research gets translated into clinical practice. Also supporting this new direction is the Clinical Research Informatics Working Group that is part of the American Medical Informatics Association. Further dialogue about this emerging domain can be found in an article in the May/June 2009 issue of the Journal of the American Medical Informatics Association.[37]

Key Points

- Traditionally, research has been paper based
- New technologies are now available to automate the research process from start to finish
- New web based collaborative sites exist to help organize and expedite research
- Electronic forms are available that are faster and more accurate for inputting information than paper-based forms

Conclusion

The evidence points towards improved productivity and accuracy using electronic collaboration tools and forms. It also seems likely that information technology can reduce full time equivalents (FTEs) due to fewer steps in data entry and data storage. The literature also suggests that data integrity is enhanced by automated data entry and validation. Multiple commercial products now exist to move research into the information age.

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21

Emerging Trends in Health Information Technology

ROBERT E HOYT
FRED TROTTER

Learning Objectives

After reading this chapter the reader should be able to:

- Identify the features of successful technology innovations
- Describe some of the future prediction by national experts
- State the significance of increased artificial intelligence in medicine
- List the innovations found at the 100 most wired hospitals that will likely permeate the healthcare system in the future

"Computers of the future may weigh no more than 1.5 tons"
Popular Mechanics 1949

"Any sufficiently advanced technology is indistinguishable from magic"
Arthur C. Clarke

Trying to predict which technology trends will succeed or fail is difficult at best and borders on pure speculation. In this chapter we will discuss some of the more significant emerging trends in technology that have applicability in the field of medicine. As previously noted, technology continues to evolve at a rate faster than our ability to digest and assimilate it into healthcare. What determines the long term success or failure of a technology trend is often unclear but seems to be partly related to the features listed in Table 21.1.

Table 21.1 Features and examples of technology trends

Features	Examples
Unique new concept	VoIP, voice recognition, digital images, RFID
Saves time or money	Voice recognition, VoIP
National mandate	E-prescribing and EHRs for Medicare physicians
Affordable	Wireless capability, cell phones, USB memory devices
Convenient form factor	PDAs, smartphones, USB memory devices
Ease of operation	USB memory devices, smartphones, PACS

Additionally, in the 2005 RAND monograph *The Diffusion and Value of Healthcare Information Technology,* Bower describes the following features that predict innovative success:

- Relative advantage over earlier innovations
- Compatibility with existing values or past experiences
- Complexity; the lower the better
- External influence by vendor marketing
- Peer pressure to try an innovation
- Network realities; the more who join, the more practical the innovation

- Degree of specialization; the broader the better
- Government policy; financial support always helps[1]

A pivotal paper was written by Bower and Christensen in 1995 in The Harvard Business Review, entitled *Disruptive Technologies: Catching the Wave.* In their work they defined disruptive technologies as overturning the dominant standard-of-care technologies. They maintained that the very technologies customers enjoy may hold back advancement and market share. Initially disruptive technologies are likely to have at least one attribute that is considered undesirable, like price, but in a short time these issues are overcome and they soon dominate the market. Sustaining technologies, on the other hand, are those that evolve slowly with the same attributes. Examples might be digital cameras replacing film photography or flash drives replacing floppy discs. At this point we have several disruptive technologies in the field of medicine such as digital radiology replacing film radiology. As electronic health records evolve they may be considered a disruptive technology.[2-3]

Medical Informatics is heavily influenced by the need to solve problems in the field of medicine, but it is also influenced by what new technologies are available. For instance, picture archiving and communication systems (PACS) are possible today solely because of innovations in monitors, servers, digital images and processors. Another example would be the increasing capabilities of the Internet made possible by greater bandwidth. Table 21.2 demonstrates how far we have come with just personal computer technology.[4] Integrating the latest developments in technology into the field of medicine will require that more healthcare workers become formally trained in technology. Healthcare administrators and chief information officers (CIOs) will also need additional education to understand new systems such as EHRs, PACS and HIOs, prior to implementation.

Table 21.2 Computer components in 1999 compared to 2009

Component	1999	2005	2009
RAM	64 MB	1 GB	3 GB
Processor speed (instructions per second)	400 million	7 billion	12 billion
Circuit density (total transistors)	7.5 million	125 million	500 million
Hard Drive (gigabytes)	8 GB	135 GB	320 GB
Internet speed (bits per second)	56,000	1 million	30 million

What Do the Experts Predict?

Health and Healthcare 2010 Study by the Institute for the Future

In this book future predictions are listed as “stormy”, “long and winding” or “sunny”. Some of the predicted information technology advances are as follows:

- Faster microprocessor speed
- Better data storage, warehousing and mining
- More wireless applications
- Better bandwidth
- More use of artificial intelligence
- Better encryption
- Internet 2
- Smaller, more accurate and less expensive sensors
- Drugs designed by computers

- Home telemonitoring
- Pharmacogenomics
- Improved imaging
    - Mini-MRIs with much smaller magnets
    - Electron beam CT instead of x-ray CT
    - More 3-D images
    - Better resolution, contrast and display
    - PET scans that use tumor specific markers instead of glucose making them more accurate
    - Computer aided diagnostic interpretations[5]

Health Care in the 21st Century

In this interesting 2005 article by Senator Bill Frist, published in the New England Journal of Medicine, changes in medical care expected to be seen by the year 2015 were:

- Highly sophisticated EHRs that are integrated with patient portals and national information networks
- Combination medications that you only have to take daily, weekly or monthly, known as "polypills"
- Implantable computer chips that monitor vital signs and blood chemistries
- Injectable nanorobots that correct problems such as blood vessel blockages
- Automatic transmission of hospital data to insurance company so bills are paid before the patient leaves the hospital[6]

In this chapter we will take a look at some of the technological trends in medicine that have appeared on the horizon. We should point out that this is only a partial enumeration of emerging trends. Some of those presented may fail and others may appear that were not predicted.

Emerging Trends

Artificial Intelligence in Medicine (AIM)

AIM has gone from a vague concept thirty years ago to new technologies such as neural networks that can aid medical diagnosis and treatment. Swartz in 1970 was very optimistic in thinking that computers would radically change the delivery of healthcare by the year 2000. He stated "*It seems probable that in the not too distant future the physician and the computer will engage in frequent dialogue, the computer continuously taking note of history, physical findings, laboratory and the like….*".[7]

Over the past thirty years universities have used artificial intelligence to develop software programs to assist medical care or what is now referred to as clinical decision support. Neural networks, a form of artificial intelligence, are data modeling tools that capture complex relationships and learn over time. An example of a neural network would be optical character recognition (OCR). A document is scanned and the image is converted to a format such as a Microsoft Word document. Each group of pixels scanned produces a value that the OCR software recognizes and converts to text. Other examples of neural networks include: target recognition, computer aided diagnosis, voice recognition and financial forecasting.[8-11]

The majority of patient information is stored as free text (to include voice recognition). This makes it difficult to extract information for coding and data mining. Companies such as Language and Computing are using natural language processing (NLP) and natural language understanding (NLU) to extract meaningful data from free text. They have entered into an agreement with Kaiser-

Permanente's Southern California region to develop a solution for evaluation and management (E&M) coding in 2008.[12] In Australia, students at Sydney University have developed the Clinical Data Analytics Language that converts physician notes to SNOMED CT using NLP. This should facilitate excellent data mining based on diagnoses.[13] As more regional and national health information networks and databases are developed it is likely that artificial intelligence will automatically analyze these data and generate reports and alerts to physicians, insurers and the government. This would eventually be more cost effective than standard chart reviews.

Better Imaging

All imaging devices have improved greatly in the past decade. In spite of the fact that imaging has not become less expensive over time, devices are smaller, faster and with better resolution. For example, Siemen's Somatom Sensation™ 64 CT scanner is one of the fastest scanners of its generation, circling the patient in 1/3 second and producing 64 images per rotation with a resolution of 0.4 millimeters.[14] One can assume that all imaging will continue to improve in the future: ultrasounds, mammograms, CT scans, MRIs, etc. As an example, ultrasound machines are now also available as portable devices with impressive features. In figures 21.1 and 21.2 the new SonoSite M-Turbo has full features to include color flow patterns and faster speed yet weighs only7 pounds.[15] As a result of this portable model, it is now used frequently in emergency rooms and in deployed military hospitals.

Figure 21.1 SonoSite M-Turbo

ColorHD™ technology captures low venous flow of the hepatic veins.

Figure 21.2 Color flow (Courtesy SonoSite)

Monitors will have higher resolution and be available in color as well as black and white. Internet-2 and Lambda Rail will merge to provide a much faster Internet. This will facilitate teleradiology and permit radiologists to simultaneously compare side-by-side old and new CTs and MRIs. With the larger pipe, images will be available on information networks for others to view remotely.

Hospitals of the future

As a rule, the more affluent hospitals are able to purchase state-of-the-art technology as a marketing edge over the competition. Every year a survey is conducted in order to nominate the United State's 100 Most Wired hospitals. Current achievements by these cutting edge hospitals will likely predict future trends in health information technology for the average hospital:

- 90% provide access to the EHR online

- 69% offer online access to nurses notes
- 88% offer lab results online
- 90% offer radiology reports online
- Most have physicians (60%) and nurses (95%) involved in IT planning and training
- Roughly 60% offer IT training as CME
- Most offer multiple patient services online such as pre-registration and disease specific self-triage
- More than 75% offer wireless access to clinical information
- Much higher adoption of bar coding and RFID[16]

Perhaps the best known of the "most wired" hospitals is the Indiana Heart Hospital built in 2003. They spent $25 million on technology, (total budget of $65 million), yet they expect a return on investment in only 6.6 years. A portion of their estimate, however, presumes decreased medical errors and legal costs as a result of going digital. One area of cost savings is from the installation of IP telephony (VoIP). This was less expensive than installing a formal private branch exchange (PBX) system. The hospital selected GE Medical Solutions throughout, to include Centricity as their EHR solution. Due to the completely digital (paperless and filmless) and wireless environment, there are no nursing stations, as nurses are located primarily in patient rooms where they have a computer for all nursing functions.[17]

Voice over Wireless Fidelity (WiFi)

There are many applications for voice over Internet Protocol (VoIP) including communication within a hospital over wireless area networks. The goal is to decrease the dependence on phone lines and pagers. The Social Security Administration is in the process of replacing its phone system with VoIP for its 1500+ field offices and 63,000 employees. The 3 year roll out will be centrally managed and run on its data network.[18] Vocera offers a hands-free device and Avaya and Cisco offer typical handsets. Vocera is a wireless device worn around the neck that follows commands thru voice recognition. The system operates on a wireless 802.11b/g network and the badge device can also send and receive telephone calls. Other options include call waiting and call forwarding, call recognition by name, function or group membership. The system can also include a nurse call button integration feature so a patient can communicate with their nurse. In 2008 a Vocera T1000 phone was added that also uses 802.11b/g with the same function as the Vocera WiFi badge.[19]

Voice recognition

As previously noted, voice recognition (VR) is a form of artificial intelligence that is catching on in healthcare. The accuracy is said to be currently in the range of 98% (out of the box by an experienced VR dictator). No longer does a clinician need to practice dictating for an extended period of time for the VR software to recognize the speech pattern. A training period of about 15 minutes using the existing software is adequate in most cases. The speed at which you can dictate has also improved dramatically and is in the 100+ words per minute range. Therefore, the learning curve is no longer steep. A separate medical vocabulary program must be purchased in addition to the basic VR software. The technology has evolved to include natural language processing, templates and macros to make the process much more robust and user-friendly. A template can structure a note in logical sections, whereas a macro can add blocks of commonly used text. Programming script can be developed to give the computer simple commands such as "*open Outlook*". Most clinicians dictate using VR into their PC with the obvious disadvantage of not being able to use the program on other PCs. This can be overcome by hosting the software on a central server or using a portable tape recorder and later syncing with the PC or using a wireless

(Bluetooth) headset. There are currently only three VR vendors that are major players: IBM, Dragon and Phillips. The most recent Dragon Naturally Speaking medical version in 2009 is 10.0 and it has 14 medical subspecialty vocabularies and can network with Citrix thin clients.[20-21]

Digital pens

Inputting data "on the fly" continues to be a challenge due to workflow demands and the need to offer more than one option to resistant physicians. One low cost option might be the use of digital pens. Logitech developed a pen that has a camera to capture data on special digital paper (expensive). It holds 2 megabytes or 40 pages of information. The pen is then synchronized to the PC. In a study by Anthem Blue Cross and Accenture, they were able to demonstrate a reduction in claims turnaround time from 4-6 weeks to 2 weeks by this method. In this study, paper claims cost $2.50 per transaction compared to 49 cents using the digital pen. In a second phase they will test a wireless solution that uses cell phones to transmit the data to the insurer.[22-23] Other vendors have now appeared on the scene. Capturx™ uses a digital pen, ordinary paper and handwriting recognition to capture medical exams followed by uploading to a customized Excel spreadsheet. A paper back-up is created as well as Excel data fields that can be mined. It has been used on a cruise line to input data on the fly and later synchronize to a personal computer.[24] Digital pads are also an interesting alternative to routine handwriting. These clip board like devices use routine paper and digital pens to capture handwriting and images and convert them to text on the PC. Instead of the $2,000 price tag for a tablet PC, most sell for about $150-200.[25]

Smartcards

France determined that it needed a universal identification card for healthcare. In 1997 they developed a smartcard that has been deployed to over 57 million consumers. A smartcard is also given to all healthcare professionals to allow access to a patient data warehouse. This card is also used for visits to dentists and pharmacies. As a result of the smartcard, reimbursement has been shortened from 6 weeks to 2-3 days. Spain, Germany, the Czech Republic and Russia are also experimenting with this type of health transaction card. Each card has a microprocessor that allows them to store, process and exchange basic medical data that can be used for emergencies and authentication. They carry enough information (32K) for an emergency and unlike most credit cards, they can be read without contact. Cards will be updated in 2009 to include better encryption and a patient photo. Figure 21.3 shows the newer Vitale 2 card.[26-27]

Figure 21.3 Vitale 2 smart card

Medical smart cards have been slow to enter the American healthcare scene. Traditionally they have been used solely for identification and authentication. The US military depends on similar smart cards for authentication, but to date the cards do not store medical information. With improved memory and other features we can expect them to find new niches. Smart cards are also being used at the Queens Health Network and University of Pittsburgh Medical Center and the St. Lukes Episcopal Health System.[28] Florida eLife Card offers 4 MB of memory with the ability to

store a complete medical history to include living wills.[29] If smart cards can be shown to expedite insurance claims payments then adoption can't be too far behind.

Memory Devices

Memory in all formats continues to improve. It is estimated that over 130 million USB flash drives were sold in 2007.[30] With the rapidly increasing memory capabilities of flash, solid state drives (SSDs) are now available. They are currently more expensive than standard hard drives but are smaller, lighter, use less current, have non-volatile memory and have no moving parts. Samsung will offer netbook vendors SSDs up to 64 GB.[31] Toshiba will market a 512 GB SSD for Japanese notebooks in 2009.[32] Corsair has released a ruggedized 32 GB flash drive that is water resistant and compatible with all Windows operating systems, so it could function as a hard drive. Operating systems such as Windows or Linux could be installed on USB memory drives along with software programs.[33] Nantero plans to introduce solid state memory composed of carbon nanotubes (one carbon atom thick) that will be incredibly fast and light. This new technology would permit instant "booting up" of a laptop. The memory will be called Nano RAM or NRAM.[34]

Radio Frequency Identification (RFID)

RFID continues to grow in popularity, particularly as prices drop and tags are miniaturized. The RFID industry is predicted to grow to $ 5.9 billion by 2009. RFID *passive* (no battery) tags are now much cheaper ($.10-$.50).[35] In the non-medical arena RFID is being used on passports, used for toll booth identification and added to credit cards for contactless identification. In the field of medicine they are primarily used for tracking of patients, medications and assets. A new twist is that *active* RFID devices can be connected to Zigbee networks. These low cost wireless personal area networks (WPANs) transmit each other's messages, thus bypassing the wired network.[36] Although *active* RFID tags are not cheap, they are durable with long battery life. Many authorities believe RFID tags will slowly replace bar coding for most common applications. Passive RFID tags will undoubtedly have more memory in the future and therefore find new indications for use. RFID receivers can be linked to existing WiFi networks which reduces cost. Hospitals have begun to use active RFID tags to track staff, patients and assets with a system known as real-time locating systems (RTLS).[37] Newer RFID tags will integrate sensors capable of transmitting temperature, decibels, etc. The University of Southern California will use RFID RTLS tags that contain temperature sensors (-28◦ C to + 90◦ C) to alert the hospital if sterilization of instruments falls outside ideal temperature ranges.[38] The future of injectable subcutaneous RFID devices for patient tracking is less certain. Although this strategy has become a standard way to identify pets, it is in its infancy with humans. Horizon Blue Cross/Blue Shield of New Jersey plans a pilot study to implant VeriChips into patients with chronic diseases to access medical information. The chip stores an identification number that correlates with an online patient medical information database. They are in the process of seeking 280 volunteers for the program.[39-40] RFID is also covered in chapter 14.

Cell phones

It seems predictable that future cell phones will be so robust that they will become a major means of pushing and pulling information, in addition to telephonic communication. In the hospital setting they have the potential to replace pagers and access patient information from the EHR or central data repository and view patient monitoring real time. They will likely connect with the computer at home and at work and be capable of paying bills. Is it possible physicians will dictate into them using voice recognition and the files are automatically sent to an EHR or PC. Security issues, however, will remain a rate limiting factor. Another area that cell phones will assist in is remote disease reporting. Mobile phones have been used to track diseases in remote areas like Rwanda.

Data can be sent to a central database via cell phone, PDA or the web.[41] As a result of this successful trial and the fact that 60% of Africa has cell phone coverage, the "Phones-for-Health" project began in 2007 to fight the spread of AIDS.[42] Cell phones are also being used to manage chronic diseases such as hypertension in the United States. In one small study, blood pressures were significantly reduced in those patients who reported blood pressure readings to their cell phones via Bluetooth. Alerts were sent to doctors and patients if the blood pressure was too high.[43]

Laptop Computers

Laptop computers have gotten smaller, lighter and faster with more than adequate RAM and processor speed. Battery life has been a limiting factor and healthcare workers may seek more functionality. There are multiple new laptops, notebooks and tablet PCs available in the healthcare field with expanding functionality. A recent laptop, Motion Computing C5, is worth mentioning as a new platform to be used in healthcare. It was designed by Intel and Motion Computing specifically for the healthcare field. Several of its notable features are as follows:

- Handwriting recognition via a digital pen
- Built-in 2.0 megapixel camera to document wounds, etc
- Bar coding and RFID capability
- Wireless and Bluetooth capability
- Biometric fingerprint reader
- Programmable buttons
- Weight of 3 lbs
- Hardened chassis and hard drive
- Ability to be wiped clean for disinfection
- 3 hour battery life with ability to swap batteries rapidly[44]

Figure 21.4 Motion Computing C5 laptop computer (Courtesy Motion Computing)

A medical laptop from Panasonic, known as the ToughBook CF-H1 Mobile Clinical Assistant, has similar features to the Motion Computing C5 laptop. Panasonic also manufactures the MDWD Wireless monitor which is a small monitor that wirelessly connects to a remote PC. It has a 8.4 inch screen, a touch screen and 300 foot range but a battery life of only 2 hours.[45] Netbook computers may be attractive to certain healthcare workers due to a smaller form factor, less expensive price tag and longer battery life.

Thin Client Technology

In the early stages of computer deployment to organizations information technology staff would often provide the user with a "dumb terminal" that would link multiple users to a single computer, in order to save money. As the price of computers dropped and the operating features improved

everyone in the organization wanted a desktop personal computer, loaded with their favorite software (fat client). Slowly this trend is reversing for some large organizations, including healthcare, that are looking to save money and simplify their operations. Thin client technology means that you have a software program on your PC that directs what you want to do on a distant server where all of your files and software programs are stored. You no longer have a hard drive, standard Microsoft Office software, etc on your PC. Your desktop station will include a keyboard, monitor, mouse, USB drive, printer and the means to connect to the network. This technology has the following advantages:

- Desktop device can be much smaller, will require less power and be less expensive to purchase and maintain
- Security is much easier as there is nothing to attack on the desktop
- Deployment and maintenance is easier and less expensive
- Data is centralized so it can be accessed from any thin client device
- Less likely to be stolen and more rugged in harsh environments
- Less network bandwidth
- Easier to upgrade hardware and software[46]

Hybrid thin-client technology exists such as "ultra thin client" and "zero client" technologies. In the zero client model there is no software or operating system on the desktop device. It does, however, require a small desktop hardware device and a separate management server.[47]

Thin client technology is being used in healthcare organizations such as the Veterans Integrated Systems Network (VISN) 23 in the northern United States that uses thin clients about 50% of the time. It is a reasonable alternative when you require a large number of computers and the same suite of software. VISN 23 reported that 80% of trouble tickets were for fat client and 20% were for thin client technology.[48] Wireless tablet PCs can also utilize the thin client model which means the device is much lighter and cooler to operate.

Web 2.0

Although there is no strict definition of Web 2.0, most people would say it is the new use of the Internet for collaborative purposes. Others argue it means using newer, richer web development applications. Rather than one person accessing one web site, it is multiple individuals taking advantage of multiple free web tools and web pages. Examples would be Wikipedia, Flickr and Clinical Informatics Wiki. Adding to this new movement would be the appearance of social networks, blogs, podcasts, vodcasts and RSS feeds.[49-51]

Clearly, Web 2.0 is beginning to affect the field of medicine. The following are examples of medical programs that are taking advantage of new Internet applications and philosophies:

- As noted in the chapter on patient informatics multiple new medical services, blogs and podcasts are appearing[52-54]
- Massachusetts Institute of Technology has developed an "opencourseware" concept that results in posting all of its course materials free to educators and learners worldwide[55]
- Universities can now post online courses using the "course management system software" known as Moodle[56]
- The Saphire Project is pushing the envelope one step further. They are part of the Semantic Web that enables applications to search for information based on its meaning, rather than tags. The European Union is sponsoring the Saphire Project that will aid in decision making

by monitoring data from wireless personal medical sensors and hospital information systems. Semantic searching overcomes the problem of interoperability[57]

- SugarStats is a diabetic program that permits uploading of blood sugar results with Twitter. Multiple health related web pages such as iHealthbeat and organizations such as the CDC and the FDA can be followed on Twitter. The reality is that more uses of this program are appearing for both clinicians and patients. New ventures are appearing constantly[58]

Cloud Computing

Just when people are comfortable with having their software located on their computers, along comes cloud computing. In essence, it means that the software is hosted on a remote server or "software as a service" (SaaS). A good example of SaaS is the EHR ASP model discussed in chapter 2. As we move closer to large scale interoperability with regional health exchanges and the NHIN we can expect to see more cloud computing. Online scheduling, consult referrals, e-prescribing and other medical processes become easier.

The advantages of cloud computing are as follows:

- No need to install or update the software. This is done for you so less IT support is needed
- Process was designed for better sharing; you can invite others to join your files on the web which cannot be done with files on your PC
- Better for mobile computing so you can access your files on the go. As we progress beyond 3 G speeds, access to the Internet will become much more rapid and make cloud computing more attractive
- Deployment is faster and costs less because of decreased IT support
- Software is often free
- It is operating system independent
- It fits with the Web 2.0 strategy and service oriented architecture
- This movement creates new competition and innovations

As with every new technological movement there are disadvantages:

- Privacy may be more of an issue
- Someone else is hosting your data
- Aspects of your data might be sold without your knowledge

Multiple large scale examples of cloud computing now exist:

- Amazon's Elastic Compute Cloud
- Google Docs
- Rackspace Cloud
- IBM Blue Cloud
- Microsoft Office Live and Windows Azure (an operating system for the cloud)
- Sun Microsystems Open Cloud Platform[59-62]

Open Source Software in Medicine

Open source software such as Apache for web servers, the GNU/Linux operating system and Firefox browser are considered mainstream programs in terms of use and acceptance. Open-source has been slower to enter the healthcare field, with the exception of the VistA EHR, but clearly is making a significant presence. Open source has often been used for a low cost alternative for community clinics and "third world" countries but many feel that open source will soon become

very competitive with proprietary products. In the chapters on EHRs, interoperability, telemedicine, bioinformatics, public health informatics and e-research we have mentioned open-source applications. Although criticized by some proprietary vendors, open-source is created by a collaborative team so frequently the end product is well thought out and more secure. The American Medical Informatics Association has an open source working group and they have published a November 2008 monograph on open-source for healthcare available on their web site.[63] Open eHealth is an open source initiative that has created the Integrated Platform that was used in the 2009 HIMSS Connectathon that helped demonstrate interoperability among different proprietary EHR vendors.[64] Wikipedia has an extensive list of over 100 healthcare software applications that covers many of the same categories as chapters in this textbook and we highly recommend this site for browsing.[65]

Readers will frequently see the acronym FOSS that stands for free open source software which requires further explanation. Free is meant to imply freedom, not price. "Free" software licenses will define the ability to copy, run and distribute the software and are determined by the Free Software Foundation. Licenses that are open source are determined by the Open Source Initiative. Public domain software has no license so it can be sold or modified and later licensed as proprietary, free or open source. For more detail on these important distinctions we refer you to these references.[63,66]

Internet2 and LambdaRail

Internet2 is a consortium (not a network) of more than 200 universities, government agencies, researchers and business groups developing applications and a network for the future. The current network is known as *Abilene* and it operates at 10 gigabits per second (100-1000 times faster than Internet1). They have deployed 13,500 miles of dedicated fiber optics as the backbone of the system. They anticipate future transmission speeds of 40-100 Gbps (7,000 times faster than a T1 line).

National LambdaRail (NLR) also connects universities (150+) across the nation through fiber optic networks. This unique network connects 28 American cities. Members benefit from using the faster Internet to communicate and from the development of interesting middleware. Research is underway to develop programs to support digital video, authentication and security. Several attempts have been made to combine Internet2 and LambdaRail but efforts thus far have been unsuccessful. Although there are no plans to make Internet2 or LambdaRail available to consumers in the immediate future, its potential in the field of medicine is tremendous.[67-69]

Biometrics

Security continues to be an ongoing issue with all technologies that store or communicate personal health information (PHI). Numerous laptop computers now offer finger print identification in lieu of signing on with a password.[70] While this is a reasonable solution for many people, certain conditions make finger prints unreliable. Retinal scanning is felt to be the most accurate biometric measure but comes with a much higher price tag. Iris imaging has also been shown to be highly accurate and has been used for authentication in the Netherlands and United Arab Emirates since 2001. Other biometric measures being used for authentication are face and hand geometry and speech recognition.[71-72] All technologies will require high tech scanners and a subject database for verification.

In February 2009 Sony announced a new biometric testing technique based on finger veins known as mofiria that scans veins below the skin.[73] Figure 21.5 demonstrates the technology. Fujitsu has similar biometric technology known as PalmSecure™ that scans the veins in the palm.[74]

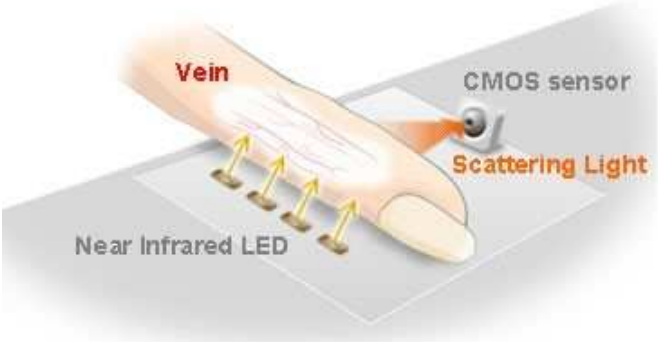

Figure 21.5 Vein scanning (Courtesy Technology Experts)

Key Points

- Technology is advancing faster than our ability to incorporate it into the field of medicine
- Expect smarter processes with natural language processing and smart cards
- Expect faster processes with Internet2/LambdaRail and voice recognition
- Expect improved laptops, imaging, RFID, flash memory and battery life

Conclusion

We live in a very exciting time in terms of rapidly improving technology. It will require highly trained clinicians who are also information technology advocates to embrace and successfully implement innovations into healthcare. More research is needed to critically appraise new information technologies before they are recommended on a large scale. Better methods will be necessary to train busy clinicians and their staff. Improved productivity, patient safety and medical quality continue to be the promise. Security, privacy, high cost and human resistance, however, will continue to be the rate limiting factors for years to come.

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